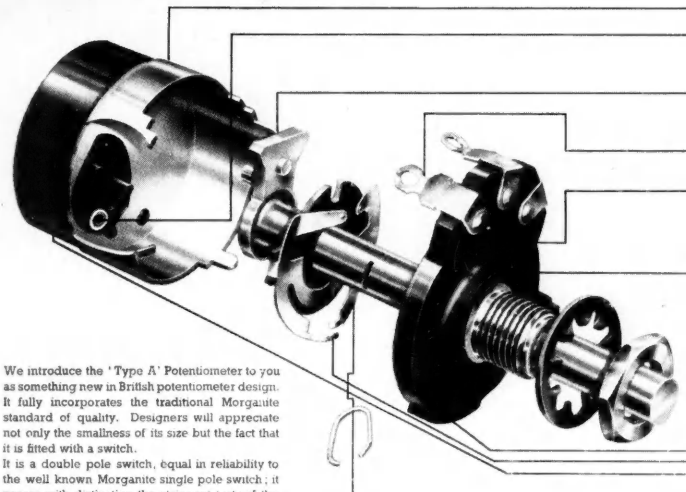
Electronic Engineering

Incorporating ... ELECTRONICS, TELEVISION & SHORT WAVE WORLD

VOL. 20 No. 247 SEPTEMBER 1948 PRICE 2/-

MORGANITE *Perfected Miniature Potentiometer*



1. OVERALL DIAMETER 1½"
2. DOUBLE OR SINGLE POLE. SWITCH OPERATED FROM SHAFT.
3. PRESSURE DIECAST ROTOR AND SHAFT: FOR ACCURACY AND STRENGTH
4. DOUBLE CLENCH TERMINALS: NOISELESS JOINTS
5. INTERCHANGEABILITY: SWITCH TO NON-SWITCH BY CHANGING COVERS
6. MORGANITE RESISTOR TRACK: LOW NOISE, HARD WEARING, WIDE RANGE OF STANDARD RESISTANCE VALUES AND GRADINGS
7. STANDARD TAPPING FIXED POSITION AVAILABLE
8. NON-TARNISHING DOUBLE PRONG SPRING CONTACTS. MINIMUM NOISE WITHOUT WEAR
9. DOUBLE POLE SWITCH PASSES SCANDINAVIAN TEST
10. INSTRUMENT QUALITY AT A LOW PRICE

We introduce the 'Type A' Potentiometer to you as something new in British potentiometer design. It fully incorporates the traditional Morganite standard of quality. Designers will appreciate not only the smallness of its size but the fact that it is fitted with a switch.
It is a double pole switch, equal in reliability to the well known Morganite single pole switch; it passes with distinction the stringent tests of the Scandinavian Electricity Authorities.

MORGANITE RESISTORS LIMITED

PAULSWAY · BEDE TRADING ESTATE · JARROW · COUNTY DURHAM

AN ANNOUNCEMENT CONCERNING

Bendix Radio

The Plessey Company Limited announce a patent arrangement with the Bendix Corporation of America whereby the internationally famous Bendix aircraft, mobile and ground radio communication systems, including navigational aids become available in Great Britain.

Manufactured at Ilford, the equipment will be completely interchangeable with the many Bendix installations already successfully operating in this country.

An introductory publication giving detailed information on the initial range of units to be manufactured is now in course of preparation. A copy will gladly be forwarded to you when published, on receipt of your business card or letterhead, attached to this announcement.

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Plessey

RADIO EQUIPMENT & COMPONENTS · AIRCRAFT ACCESSORIES
ELECTRICAL & MECHANICAL PRODUCTS

AN ANNOUNCEMENT OF THE PLESSEY COMPANY LIMITED ILFORD ESSEX

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CLASSIFIED ANNOUNCEMENTS

The charge for these advertisements is twelve words or less 5/- and 4d. for every additional word. Box number 2/- extra, except in the case of advertisements in "Situations Wanted" when it is added free of charge. A remittance must accompany the advertisement. Replies to box numbers should be addressed to: Morgan Bros. (Publishers) Ltd., 28, Essex Street, Strand, London, W.C.2 and marked "Electronic Engineering." Advertisements must be received before the 10th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

Vacancies advertised are restricted to persons or employments excepted from the provisions of the Control of Engagement Order, 1947.

THE CIVIL SERVICE COMMISSIONERS give notice of a Supplementary Reconstruction Competition for pensionable appointment to the Assistant (Scientific) class. Candidates must have attained age 18 by 1st January, 1948, and must produce evidence of thorough experience in the duties of the class gained by service in a Government department or other civilian scientific establishment or in technical branches of the Forces, covering a minimum of two years in one of the following groups of scientific subjects: (i) Biological sciences; (ii) Chemistry, bio-chemistry and metallurgy; (iii) Engineering and physical sciences; (iv) General (including geology, general work ranging over two or more of groups (i) to (iii) and highly-skilled work on laboratory crafts such as glass-blowing). Candidates born on or after 1st January, 1917, must, in addition, produce evidence of having reached a prescribed standard of education, particularly in a science subject. Salary for Assistant Grade, £195-£380 (men), £195-£320 (women), Senior Assistant Grade, £400-£550 (men), £330-£440 (women), rather less outside London. Opportunities for promotion to higher grades. Further particulars and application forms from the Secretary, Civil Service Commission, Scientific Branch, 27, Grosvenor Square, London, W.1. Completed application forms must be returned by 31st October, 1948.

THE RADIOCHEMICAL CENTRE. Applications are invited for the following appointments: (a) A Physicist is required to take charge of the radiation health services in a group of laboratories where radioactive materials are handled. A hospital Physicist who has worked with radium or radon, or one with similar experience of applied nuclear physics will be most suitable for this post, which is concerned with the detection of radiation hazards and the organisation of protection against them. (b) A Physicist, preferably with previous experience of radiation measurements, is required to take charge of a section engaged in the standardisation of natural and artificial radioactive substances. Applicants should be men of good professional standing, who are capable of developing the work on their own initiative and collaborating with other institutions. They will be required to pass a medical examination, and should be between the ages of 25 and 45. Good salaries will be offered to those having the required experience and qualifications. A superannuation scheme is in force, and in some cases housing will be available at Amersham. Successful candidates will be appointed to the staff of Thorium Ltd. (Managing Agents to the Minister of Supply), to whom applications should be sent at The Radiochemical Centre, White Lion Road, Amersham, Buckinghamshire.

SITUATIONS VACANT

THE ENGLISH ELECTRIC VALVE COMPANY invites applications for a Valve Engineer for the research laboratory. This is a senior appointment calling for an essentially practical man with wide experience in the design and manufacture of electronic tubes. A Science Degree together with a knowledge of photo-electric processes would be advantageous. The applicant should be a good organiser and capable of controlling staff. Remuneration will be according to age, qualifications and experience. Apply giving full details of age, qualifications and salary required to, Chief of Research, English Electric Valve Co., Ltd., Waterhouse Lane, Chelmsford.

BOROUGH POLYTECHNIC, Borough Road, S.E.1, Department of Electrical Engineering and Physics. The Governing Body invite applications from suitably qualified men for appointment as Laboratory Steward in the radio laboratories of the Department of Electrical Engineering. Applicants should have some knowledge of radio engineering up to the standard of City and Guilds Grade II examination, and have had practical experience in servicing radio equipment. The salary will be in accordance with the scale of £275 per annum, rising by annual increments of £20 to £355. The successful candidate will be eligible for admission to the superannuation scheme. Applications should be made in writing, stating age, qualifications and experience, to the Secretary.

ELECTRIC AND MUSICAL INDUSTRIES LTD., have vacancies for the following drawing office personnel, on electronic, telecommunication and electro-mechanical engineering: (a) Senior Electro-mechanical Designer-Draughtsmen. (b) Senior Mechanical Designer-Draughtsmen. (c) Senior Electrical Designer-Draughtsmen. (d) Detail Draughtsmen. Apply, stating age, fullest details of experience and salary required to Personnel Department, E.M.I. Ltd., Blyth Road, Hayes, Middlesex.

A NUMBER OF CHEMISTS and Physicists required for a new research station in Essex. Applicants should have a good degree in Chemistry or Physics, with preferably a few years' experience in industrial research or development on electronics. Housing accommodation will be provided for the right type of keen and ambitious workers. Salary of £500-£700 per annum. Apply, stating age, qualifications, experience, etc., to Box 335, E.E.

PHYSICISTS required for instrument research by West London aero engine manufacturers. Experience of industrial instrumentation desirable. Full details, qualifications, experience and salary required to Box No. A.C. 132, c/o Central News, 17, Moorgate, London, E.C.4.

A LARGE VALVE MANUFACTURER (S.W. London) require graduates in Physics or Electrical Engineering as Assistants in their Transmitting Valve Development Department. Should have had some experience of design or manufacture of transmitting valves and should be capable of working in this field under direction. Salary £400 plus, according to age, experience and qualifications. Reply to Box EE587, L.P.E., 110, St. Martin's Lane, W.C.2. Quote reference T/222.

RADIO ENGINEER required, with experience of acoustics, audio-frequency technique and circuit work, to take charge of Development Laboratory. Good academic qualifications essential; experience of engineering for production an advantage. Write, giving full particulars and stating salary required. Box M. 3727, Haddons, Salisbury Square, E.C.4.

GLASSBLOWER required for Research Laboratories. Must have good all-round experience in hard and soft glasses and glass lathe experience. Apply in person or write to Personnel Department, E.M.I. Ltd., Blyth Road, Hayes, Middlesex.

MEDICAL ELECTRONICS. A vacancy arises for an Electronic Engineer (sales) in the Electro-Medical Department of a large London company. The candidate, in addition to possessing technical qualifications equal to final City and Guilds standard (Radio Communications), should be willing to travel, and should have some commercial acumen, as his duties are mainly concerned with technical/commercial sales of electro-medical equipment. Apply, in the first instance, in writing, stating qualifications, experience, age, etc., to Box 326, E.E.

SENIOR ENGINEER required to take charge of department engaged on the practical development of microwave radio. Technical qualifications to degree standard and previous experience are essential. State full details of qualifications, experience, age, and salary required to Box 325, E.E.

OPPORTUNITY FOR YOUNG MEN, preferably 25/30, wishing to travel. Good pay and allowances with prospects. Extensive service experience army and navy radar and radio essential, academic qualifications not essential. Apply Box 331, E.E.

VALVE ENGINEER required to take technical control of production and development work on quantity production of vacuum tubes for one of the leading firms in this country. The qualifications required are an Honours Degree or its equivalent, with considerable experience in both development and production problems in vacuum tube manufacture, including cathode ray tubes. Applicants should be about 30 to 35 years old and possess the personality and drive required for the effective control of personnel as well as the ability to handle technical problems. Salary would be determined according to age and experience. Write fully to Box 327, E.E.

PRODUCTION SUPERVISOR required. Must have previous experience of modern radio assembly methods, coupled with fair working knowledge of rate fixing and machine shop practice. Good disciplinarian. Five-day week, canteen and welfare facilities. Write, giving full particulars of past experience and state salary expected. Box A. 1287, Haddons, Salisbury Square, London, E.C.4.

CONTINUED EXPANSION AT E.M.I. INSTITUTES has created further vacancies for Lecturers in Radio Communications. Three lecturers, whose duties will include some technical writing, are required by September, 1948. Applicants should possess a good Physics or Electrical Engineering degree, and also experience in radio. Knowledge of television or radar an advantage. Age 22-28. Commencing salary, according to age, qualifications and experience, not less than appropriate Burnham scale. Superannuation benefits in addition. Apply, giving fullest possible particulars to Professor H. F. Trewman, M.A. (Cantab.), M.I.E.E., M.I.Mech.E., M.Brit.I.R.E., 43, Grove Park Road, London, W.4.

LABORATORY TECHNICIAN for audio-frequency development work with Medical Research Council Unit in London. Good qualifications required. Excellent prospects. Box 329, E.E.

THE MULLARD RADIO VALVE COMPANY require Graduates in Physics or Electrical Engineering as Senior Assistants in their Cathode Ray Tube Development Department. Must have had experience in design of cathode ray tubes or similar articles, should have a knowledge of electron optics and tube structures, and be capable of originating and supervising development work. A salary commensurate with the responsibility of the work and with the age, experience, and qualifications of the applicant will be paid. Write in first instance for form of application to Works Personnel Officer, Mullard Radio Valve Co., Ltd., New Road, Mitcham Junction, Surrey, quoting the reference W.4.

A LARGE MANUFACTURING CONCERN situated south of the Thames in the London area invites applications from experienced Time Study Engineers for vacancies carrying a salary from £500 to £700 per annum. A knowledge of the Bedaux system is essential and no application can be entertained without the above qualification. Write, giving full details of experience, and state salary required to Box EE739, L.P.E., 110, St. Martin's Lane, W.C.2.

ELECTRONIC ENGINEERS required for the testing and/or development of precision audio and radio frequency measuring apparatus. City and Guilds Final in Radio Communications is the standard of training required, coupled with practical experience. Congenial working conditions and a pension scheme. H. W. Sullivan Ltd., Leo Street, Peckham, S.E.15.

SALES ENGINEER to specialise in automobile radio equipment. Experience in comparable field and adequate training essential. Technical qualifications desirable. Age 25-30. Excellent prospects with leading London manufacturers. Salary according to experience. Box 337, E.E.

LOUDSPEAKER ENGINEER, Senior, required. Good opportunity and salary for man with specialised experience in the industry over a number of years. Give full details of experience. All replies treated in confidence. Box 340, E.E.

TELEVISION ENGINEER required for development work by large manufacturer in the East London area. Essential experience is at least two years in recognised laboratory engaged on television development and adequate technical knowledge. State full details of experience, age and salary required to Box 339, E.E.

WANTED FOR EMPLOYMENT in various parts of England, Scotland, Wales and North Ireland, personnel experienced in Thermionics. Required for employment as maintenance and repair of radar and fire control apparatus. Pay varies from 110/- per week to £625 per year according to type of work for which selected. Applicants should furnish full details of practical experience, age and technical qualifications held. They should also state in which part of the U.K. they would like to be employed. Replies to:—D.D.M.E., H.Q.A.A. Command, Stanmore, Middlesex.

CLASSIFIED ANNOUNCEMENTS (Cont'd.)

SITUATIONS WANTED

RADIO ENGINEER, 24, studying C. and G., Brit.I.R.E. examinations, desires junior post, radio or allied. Home or overseas. Experienced production supervising. Box 334, E.E.

ENGINEER - DRAUGHTSMAN (42), excellent qualifications, 20 years' experience design and mass production, seeks position of responsibility, chief draughtsman, etc., industrial electronic control. For full details please write Box 328, E.E.

SENIOR ENGINEER, qualified, practical, 12 years' design experience, communication, domestic equipment, desires senior position. Box 332, E.E.

GENERAL MANAGER, Electronics or Radio, for Sales and Export, with responsibility for development and production. 15 years' experience. London University trained to B.Sc. standard, M.Brit.I.R.E., A.M.I.E.E., with foreign languages and experience abroad. Box 338, E.E.

EDUCATIONAL

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY ELECTRICAL ENGINEERING DEPARTMENT

The following Post-Graduate Courses of 8-10 lectures have been arranged for the Christmas term: (1) "Advanced Electro-magnetism and Electron Dynamics," at 3.45 p.m. on Wednesdays, commencing October 6—lecturer, Dr. D. Gabor, Research Laboratories, British Thomson-Houston Co., Ltd. (2) "Some Physical Aspects of Advanced Electric Circuit Theory," at 3.45 p.m. on Mondays, commencing October 11—lecturer, E. C. Cherry, M.Sc., Imperial College. Syllabuses of the courses may be obtained from Deputy Registrar, City and Guilds College, Imperial College, Exhibition Road, S.W.7, to whom those wishing to attend should send particulars of their academic qualifications and experience, not later than Wednesday, September 29. Fee for each course, 2½ gns. Other advanced courses have been arranged for the Lent and Summer terms on the following subjects: Speech Synthesis and Compression, Electronic Emission from Solids, Theory of Aerials, Power System Analysis and Engineering Problems Arising in the Utilisation of Atomic Energy. Further particulars will be published later.

NEW METHODS IN RADIO SERVICING. Full details and publication, "Modern Radio Servicing" free. BCM/CIRCUIT, London, W.C.1.

SERVICE

LOUDSPEAKER repairs, British, American, any make, moderate prices.—Sinclair Speakers, 12, Pembroke Street, London, N.1.

RADIO MANUFACTURERS can undertake development and assembly of radio or electronic equipment. Winding shop with vacuum impregnation plant. Ample space and labour available. Box 316, E.E.

REWINDING. A specialist winding service covering A.F. transformers, relays, solenoids, and to specification. S.T.S., Ltd., 297/299, High Street, Croydon, Surrey. Telephone: CROydon 4870.

CAVILL PRODUCTS LTD. can now accept commissions as consultants and engineers for all electronic problems. Enquiries: Electronic Research Department, Cavill Products Ltd., 73, Camden Road, N.W.1.

MISCELLANEOUS

WE WILL BUY at your price used radios, amplifiers, converters, test meters, motors, pick-ups, speakers, etc., radio and electrical accessories. Write, phone or call, University Radio Ltd., 22, Lisle Street, London, W.C.2. GERard 4447.

PHOTOGRAPHY. We specialise in advertising and catalogue-photography, and in series photographs for instruction sheets. Our pictures tell the story. Behr Photography, 44, Temple Fortune Lane, N.W.11 (SPEedwell 4298).

AMERICAN RADIO and general periodicals by subscription. Stamp for catalogue. B. H. Warren, Wynscote, Wilburton, Ely, Cambs.

FOR SALE

WEBB'S 1948 Radio Map of World, new multi-colour printing with up-to-date call signs and fresh information; on heavy art paper, 4s. 6d., post 6d. On linen on rollers, 11s. 6d. post 9d.

IN STOCK. Rectifiers, Accumulator Chargers, Rotary Converters, P.A. Amplifiers, Mikes, Mains Transformers, Speakers of most types, Test Meters, etc. Special Transformers quoted for.—University Radio, Ltd., 22, Lisle Street, London, W.C.2. GERrard 4447.

TELEVISION AERIALS. Baldwin Instrument Co., Ltd., have for disposal a limited number of sets of duralumin tubes cut to correct length suitable for television aerials. Price, carriage paid, dipole only 15s., dipole and reflector 25s. Cash with order or C.O.D. Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.

FOR SALE, 1 rotary transformer; 1 power pack, output 1,000 volts; 1 small power pack, untested output; 1 Zenith "Variac," 100R, new; 1 Furzehill diode voltmeter, new; 1 AVO model 40, new; 1 galvanometer 25-0-25, and various other items of electrical equipment. List on application to Box 336, E.E.

1948 VADE MECUM listing 10,000 valves. Universal Services, 13, Newburgh Street, London, W.1.

COPPER WIRES: enamelled, tinned, Litz, cotton, silk covered. All gauges. B.A. screws, nuts, washers, soldering tags, eyelets. Ebonite and laminated Bakelite panels, tubes. Paxolin coil formers. Tufnol rod. Permanent detectors, etc. List S.A.E. Trade supplied. Post Radio Supplies, 33, Bourne Gardens, London, E.4.

FLUORESCENT LIGHTING. 230V 80 watt A.C. choke-capacitor unit, holders, glow starter, ready to instal less 5-ft. tube, only 47s. 6d. 1KW transformers, 220-110V, fully cased, £4. Malden Transformer Supplies, 39, Malden Road, New Malden, Surrey.

1 BRAND NEW complete M.S.S. recording machine; 1 matching transformer; 1 B.S.R. 20-watt amplifier; 1 lightweight pick-up with permanent sapphire needle; 1 P.U. matching transformer; 20 cutting needles; 24—5-in. blank discs; 30—8-in. blank discs; 15—12-in. blank discs; 25—6-in. blank discs; 30—10-in. blank discs; 1,000 trailer needles; 1 Lustraphone M.C. microphone and table stand. All brand new and very little used. What offers? Box 333, E.E.

S.T.C. 3-in. oscilloscope, model 7433A, also Muirhead valve voltmeter, type 3-A, 0—2V, 0—10V, 0—50V; £15 each or offers to Box No. 3661 c/o White's Ltd., 72, Fleet Street, London, E.C.4.

MAINS TRANSFORMERS, 16s. 6d.; coil packs LMS 465 Kc/s., 15s.; I.F. transformers, 465 Kc/s., iron-cored, 9s.; solder tags, eyelets, etc., 1s. gross. Ins. sleeving from 1d. yard. Send for cheapest list in England. Sussex Electronics Ltd., 4, Upper Bevendean Avenue, Brighton 4446.

RELAYS, RELAYS, RELAYS, 150 types, also 12/24V cut-outs, starter switches. Telephone components, carbon insets, switch keys, jacks, plugs, selector switches, handsets, cords, 4½V solenoid with ratchet action, drop indicator jacks. Block condensers including 250 mF. 6V electrolytic. High-speed relays. 12/24V indicator lamps, jacks and lenses. Jack Davis, Dept. E.E., 30, Percy Street, London, W.1. MUSeum 7960.

VARIABLE SELECTIVITY I.F. transformer, 465 Kc/s., three degrees selectivity, wound Litz wire on polythene former: 12s. each. I.F. transformer with balanced centre tap primary and secondary windings for A.F.C. or crystal filter circuits, etc.: 12s. each. Radio Components, East Street, Darlington.

PHASE SHIFTING TRANSFORMERS. Input, 230V 50 cycles, output, 75V 2 watts. Suitable thyratron control, etc., 25s. Selector switches. Impulse motor drives 4-way wafer switch, 2s. 6d. Both post free. Wanted, bombload preselector switches 32-point, type B, or similar. Box 330, E.E.

MAGSLIPS, all 50V 50 c.p.s. operation. 3-in. transmitters, 27s. 6d.; 2-in. transmitters, 30s.; 2-in. receivers (for remote indication), 25s.; small quantities of other types available, enquiries (incl. those of a technical nature) invited. Linear wire-wound Pots. Berco type M10, 10 watt, 1,000 ohms, 4s. 9d.; 50K. ohms, 5s.; particularly suitable for bridge-type instruments. 2-gang pots, 1 meg.-1 meg., 3s. 3d. Mains transformers, 350-0-350 200 mA, 6.3V 7A, 6.3V 2A, 5V 3A, input 200-240V, 27s. 6d. Resistances, 470K, 10 per cent., ½ watt, 100K, 10 per cent., ½ watt, 500 ohms 2 watt wirewound, 1.5 ohms 5 watt vitreous, all at 7s. 6d. per 100. All goods ex Government, but perfect and guaranteed, post free, Hopton Radio, 1, Hopton Parade, Streatham High Road, London, S.W.16. STReatham 6165.

THE ENOCK PICKUP armature, or more correctly, coil former, is precision moulded in a special plastic material. It combines absolute rigidity with extreme lightness, and has no self-resonance within the audio range. It also makes an ideal setting for the polished diamond stylus, which is moulded in by our exclusive method (patents pending).

The demand for the Enock Pickup (also licenced under Patent No. 538,058) has been unexpectedly large and, as a result, we have been able to make considerable reductions in production costs. We take pleasure, therefore, in announcing a reduction in price to £29 5s., including tax. Telephone or write for a demonstration. Joseph Enock Ltd., 273a, High Street, Brentford, Middlesex. EALing 8103.

THE MORDAUNT DUPLEX REPRODUCER incorporates a multiple taper folded horn in the bass section. This is driven by a 12-in. 18,000 lines p.m. unit through a correctly designed throat chamber, and results in high efficiency and large power handling capacity, combined with low harmonic distortion and freedom from inter-modulation. The bass resonance usually associated with systems utilising resonant chambers and baffle mountings is non-existent, and an exceptionally smooth response is obtained down to below 40 c.p.s. Musically speaking, here at last is a loudspeaker which provides the right quality foundation for the rest of the music to "sit on," and this contributes its correct quota for re-creating the original sounds. Telephone or write for a demonstration. Joseph Enock Ltd., 273a, High Street, Brentford, Middlesex. EALing 8103.

THE ENOCK AMPLIFIER is expressly designed to obtain the highest possible standard of performance without regard to first cost. The output is 15 watts (two triodes in push-pull) and the total distortion, including noise, is 0.1 of 1 per cent. Hum level —75db. Frequency response is flat from 20 to 30,000 c.p.s. There are no electrolytic condensers whatsoever in the amplifier. Gramophone and radio inputs are provided. The pre-amplifier is a separate unit for mounting direct on the control panel or motor board and is low impedance, coupled to main amplifier. It contains all the controls, thus eliminating flexible couplings and any hum pickup due to long leads. Telephone or write for a demonstration. Joseph Enock Ltd., 273a, High Street, Brentford, Middlesex. EALing 8103.

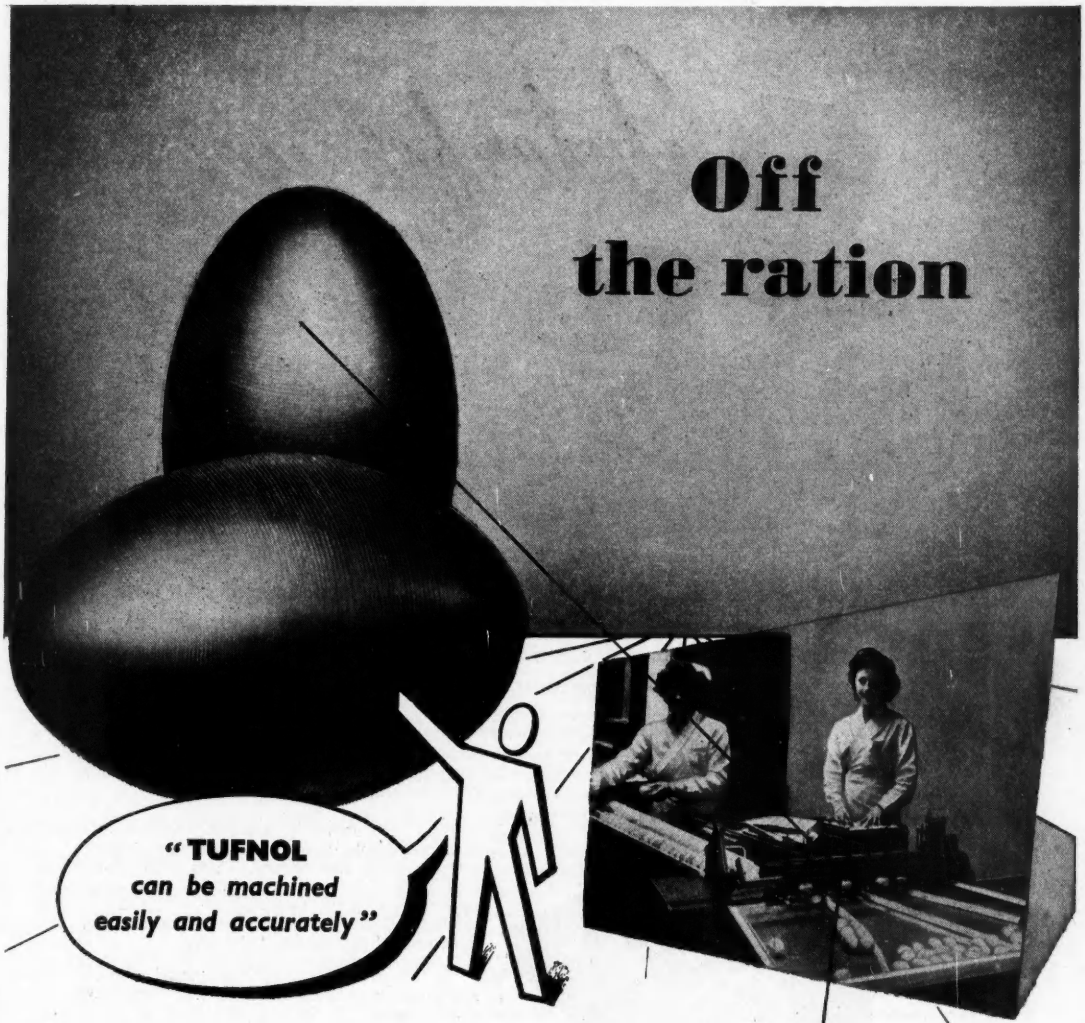
TELEVISOR PARTS. Vision and sound panel chassis, time base and power base chassis, all resistors (Erie) and T.C.C. condensers, exactly as specified for TELEVISOR. Belling and Lee components, etc., etc. Everything in stock. Trade only. Petter Radio Supplies, 203, Forest Road, Walthamstow, E.17.

TELEVISION for £15

There are available ex-Government radio receivers and indicators which can be turned into Television Receivers—our publication "The £15 Television Receiver" gives explanations and circuit diagrams, and in a not too technical manner, it shows you how to do it. Price 7/6 post free.

W. D. SALES, 4 ELECTRON HOUSE, WINDMILL HILL, RUISLIP MANOR, Mdx. Open Saturday till 5 p.m.

Off the ration



Yes, this *is* an egg—made of Tufnol . . . it is a standard for weight in an egg grading machine. Tufnol was selected because it could be machined easily and accurately.

In addition, Tufnol has many valuable physical properties — lightness in weight, good mechanical strength, and resistance to corrosion. Engineers in every industry are finding the value of Tufnol, in thousands of different ways.

Our Engineers will gladly help you

TUFNOL LTD · PERRY BARR · BIRMINGHAM 22B

TUFNOL

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Interference? never heard of it!

Never had your favourite programmes spoilt by a background of hissing, crackling and spluttering noises? No? Lucky you! But for thousands living in towns and cities near industrial electrical apparatus, near trolley-bus routes or in the vicinity of high frequency equipment such interference is only too common.

B.I.Callender's Anti-Interference Aerial, when properly erected, will give you better listening and reveal many stations you never heard before.

The aerial is a 60-ft. polyethylene insulated dipole type with suspension insulator and matching transformer. The 80-ft. down lead is a fully screened coaxial cable with polyethylene plugs moulded to each end; it is matched to the receiver by a transformer with easily fixed suction mounting.

It acts as a " T "-type aerial on long and medium waves and as a true dipole on short waves.

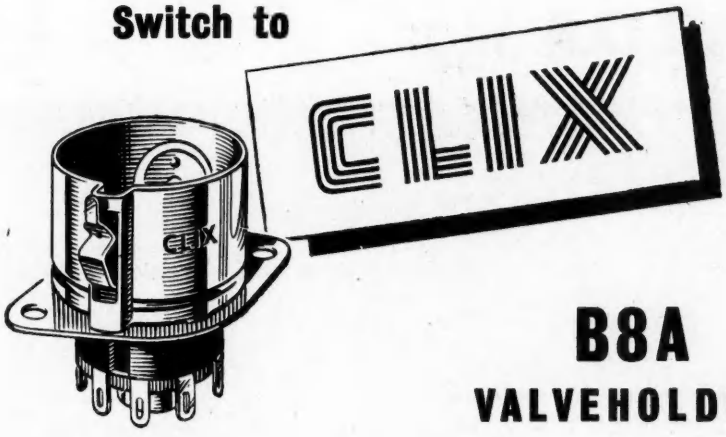
Write to-day for descriptive folder No. 221 N on " Anti-Interference Aerial."

Licensed under Amy Aceves & King, Inc., Patents Nos. 413917, 424239 *and* 491220.

B.I. Callender's *All-Wave* ANTI-INTERFERENCE **AERIAL**

BRITISH INSULATED CALLENDER'S CABLES LIMITED
NORFOLK HOUSE, NORFOLK STREET, LONDON, W.C.2

Switch to



B8A
VALVEHOLDERS

Used by all leading set manufacturers

The Clix B8A valveholder is fitted as standard equipment in most modern radio and television sets. It is designed to give maximum ease of fitting and minimum capacity and contact resistance with the new all-glass B8A valves. The plated pin sockets eliminate corrosion and make the valve easy to insert or withdraw, but when it is in the holder, the valve is held firmly by the patent Clix retaining latch. Saddle and screen are also plated to reduce contact resistance. The body of the holder consists of a robust moulding and all dimensions are to British Standard Specification : Fixing centre $1\frac{1}{8}$". Hole diameter $\frac{1}{8}$".

Clix Valveholders are protected by British and Foreign Patents.

GAC CLIX ELECTRICAL RADIO & TELEVISION ACCESSORIES

THE GENERAL ACCESSORIES CO. LTD.

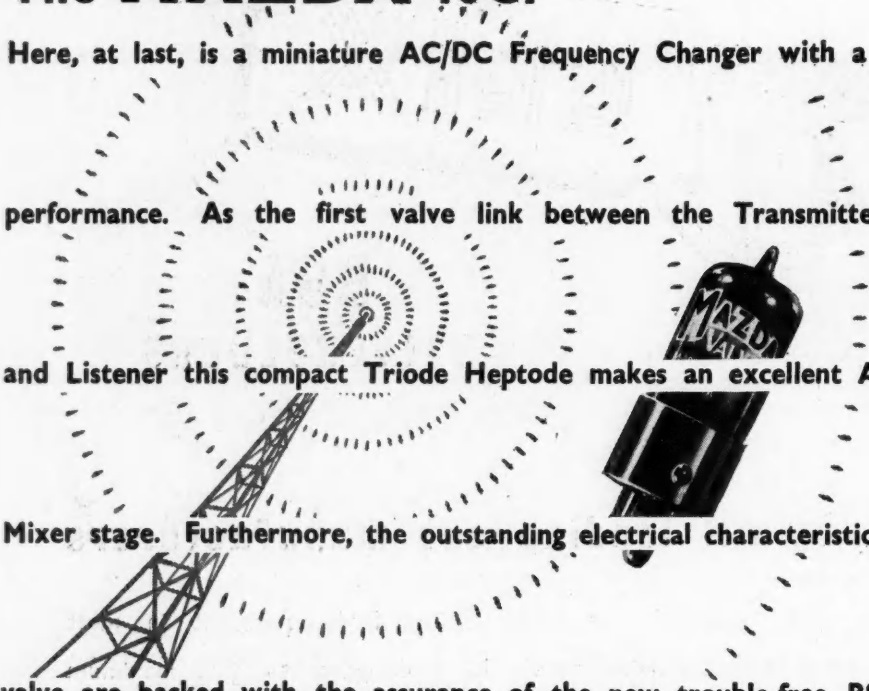
Manufacturers of Good Electrical Accessories since 1896

21 BRUTON STREET, LONDON, W.1 *Phone: MAYfair 5543*

RATED FOR DEPENDABILITY

The MAZDA 10C1

Here, at last, is a miniature AC/DC Frequency Changer with a superior performance. As the first valve link between the Transmitter Aerial and Listener this compact Triode Heptode makes an excellent All Wave Mixer stage. Furthermore, the outstanding electrical characteristics of this valve are backed with the assurance of the new trouble-free B8A base.



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Maximum Screen Voltage (volts)	250	—
Mutual Conductance (mA/V)	*2.5	†4.0
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*Va_h=175v. Vg=0 †Va_t=100v Vg_t=0

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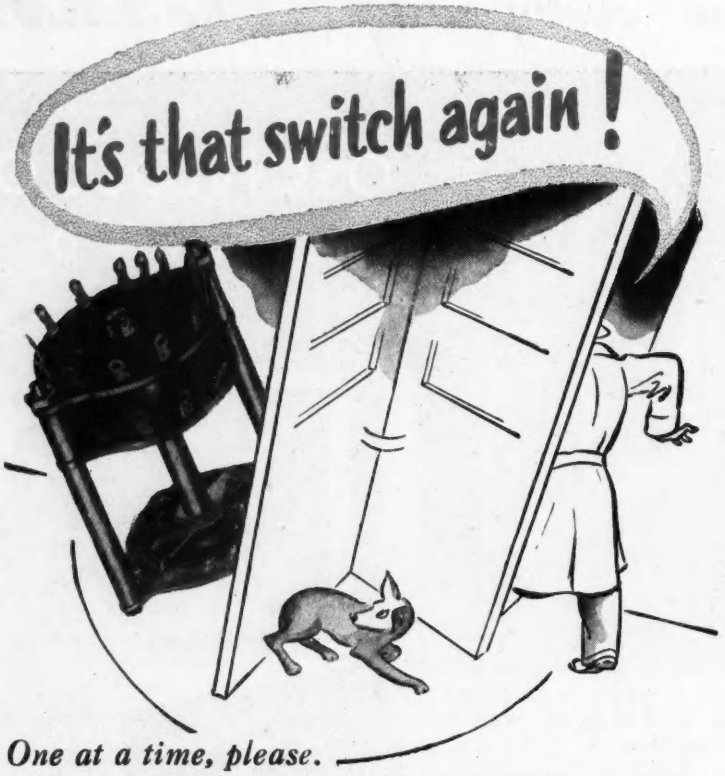

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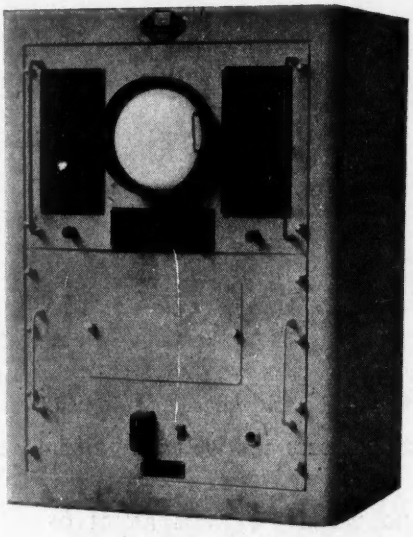

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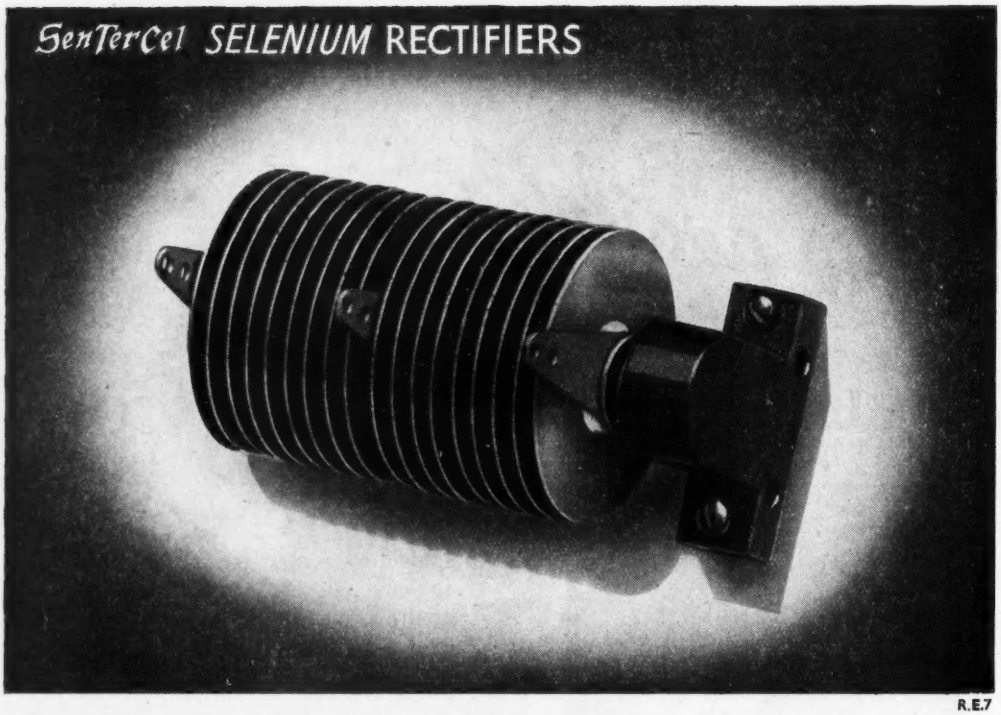

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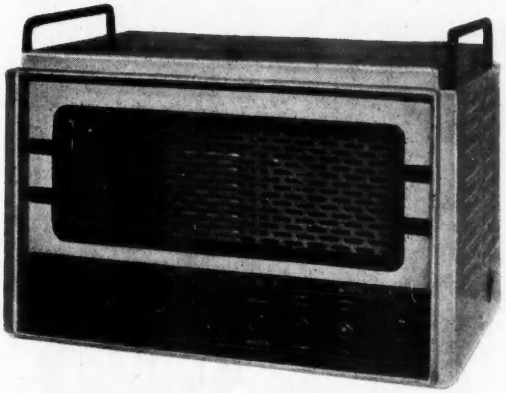

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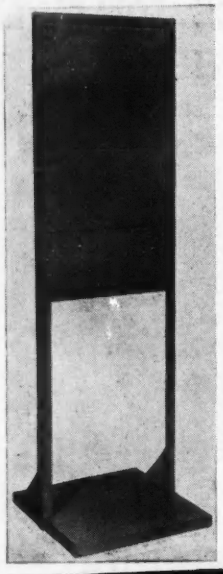

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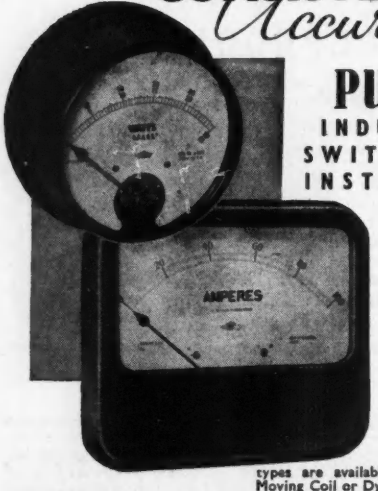

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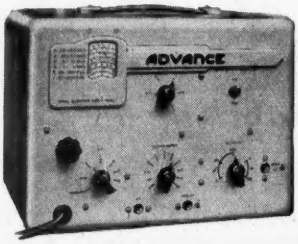

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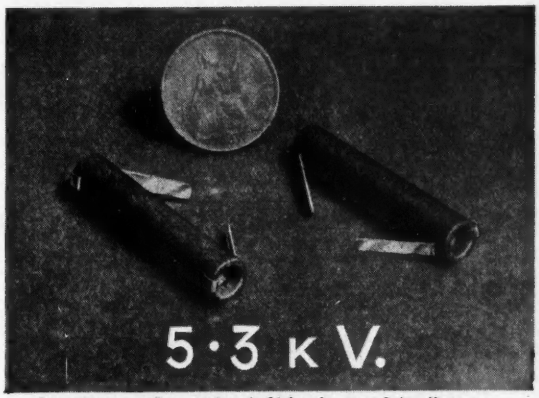

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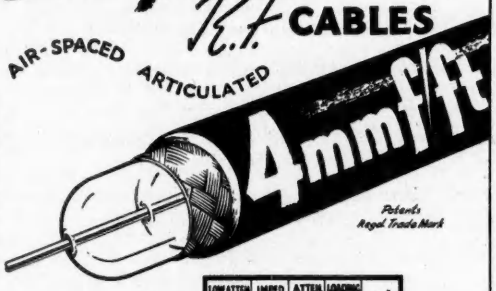

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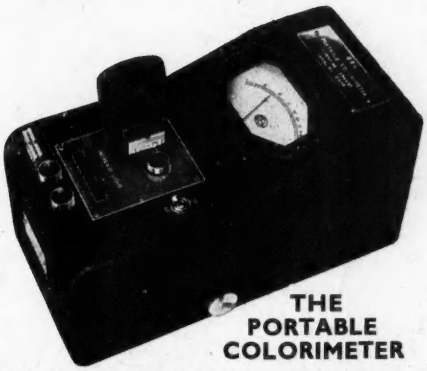

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CONSTRUCTION. In construction, the tube resembles a radio valve of the all-glass loctal type.

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Max. Starting Voltage	125V
Current Range	1—8mA
Operating Current	4½mA
Internal Resistance at 4½mA	290 ohms

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British Television

THE televising of the Olympic Games was a triumph for the Outside Broadcasting Unit and has given a stimulus to British television at the right time. More than 60 hours transmission over and above the regular programmes gave the public a chance to see what television really means as a home entertainment, and was incidentally a good endurance test for receivers, which are seldom called on to operate continuously for eight hours at a time.

The announcement by one manufacturer of a new receiver model at a very reasonable price should also be an encouragement to the would-be buyers who have not yet decided that 365 days of real entertainment in the home is well worth the expenditure.

The amount of sales resistance to television which is still encountered is surprising. Having once made up their minds that (a) there is something better up the sleeve of the B.B.C., and (b) prices will come down with a run, some non-viewers seem to be impervious to facts or argument to the contrary. It has been repeated over and over again that the present system will not be changed for many years and that receivers will not become obsolete. It can also be demonstrated that the television receiver is more complicated than a radio receiver and therefore costs more. But there are some who still look wistfully at their friend's screen and say "I will get one when they are as cheap as battery sets, and I expect they will have got colour by then!"

In this issue we are pleased to be able to include a pictorial record of the work that goes on behind the production of the television programme. Unfortunately no photographs can reproduce the spirit of enthusiasm which pervades the whole of the staff at Alexandra Palace. The fortunate visitor is able to sense it and leaves the Palace with admiration for the people who do a first-class job under conditions which are far from adequate. The area occupied by the studios and offices is a very small part of the total area enclosed by the Palace walls, which most of the time only echo the footsteps of a stray individual. The ordinary viewer, who has no knowledge of complicated policies or trusteeships, may well wonder why the Palace has not been turned into a London Television Centre where he might see his favourite artist in the flesh as well as on the screen, or take part in a real Café Continental.

But we may be underestimating the willingness on the part of the authorities to encourage such an enterprise. Covent Garden has been acquired by compulsory purchase, and even now an Order may be in the making to present the B.B.C. with a space worthy of their talent. Who knows? In the meantime, hats off to British Television and the men behind it!

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The Infra-Red Image Converter Tube

By T. H. PRATT*

Based on a Lecture delivered before the Electronics Group of The Institute of Physics on November, 4th., 1947

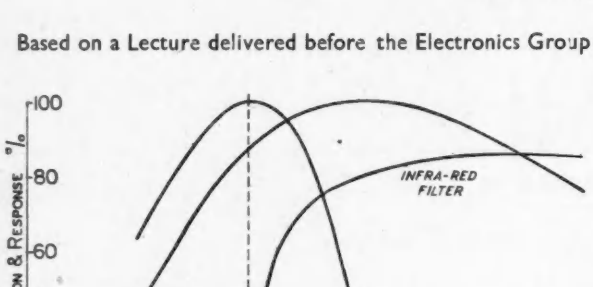


Fig. 1. The near infra-red region of the spectrum

THE principle of the infra-red image converter tube is not new but it has only been with the development of equipment for Service applications that any particular interest has been shown in such devices. In principle the image converter is a system for rendering visible radiation of wavelengths lying outside the range of spectral sensitivity of the human eye. Several tubes have been described in the scientific journals, and the wartime work has consisted of the development of operationally serviceable equipment based on the principles given in the published accounts. In particular, equipment has been produced for Service use that transforms an image in the near infra-red spectral region into an image visible to the eye.

It is, perhaps, appropriate first to make a brief reference to this near infra-red region of the electromagnetic spectrum which lies between about 8,000 and 13,000 Angstroms (0.8 and 1.3 microns). The lower wavelength represents the approximate long wave limit of the response of the eye,[1] while the upper figure is the long-wave limit of sensitivity of most of the photodetectors available for use in this region.

Transmission of near infra-red radiation through the atmosphere is virtually the same as that of visible light. In particular it should be noted that at wavelengths so slightly removed from the visible, no useful advantage is obtained in conditions of mist or fog. The tungsten filament lamp running at normal colour temperatures (say 2,800° K.) is, of course, an extremely efficient source of radiation in the region of one micron, and was used in all Service applications.

The main phenomena used for detection in the region are photography, photoconductivity, phosphorescence and photoemission. In the case of the first of these, the sensitivity of the photographic plate can be extended to about 1.3 microns by the use of a suitable dyestuff such as pentacarbocyanine[2] to absorb radiation and transfer the energy to the main silver bromide lattice. Results obtained in long range aerial photography using infra-red plates have led to the widespread impression that near infra-red radiation will penetrate mist, but it must be stressed that the increased atmospheric penetration is only obtained through the small particle haze that is present even under conditions of the best visibility. Photoconductivity and phosphorescence rely, as does the photographic plate, on an internal photoelectric effect. In the former, absorption of radiation raises electrons to the conduction level from impurity centres in a semi-conductor lattice, with a corresponding variation in resistance, while in the case of phosphorescence, electrons that have been raised into trapping centres by some activation process, are removed from these centres by the infra-red radiation and return to the ground level with the emission of visible radiation. The best known photo-conductor in this region is thallium sulphide,[3] while typical of an infra-red sensitive phosphor is strontium sulphide sensitised with samarium and europium.[4] In the case of photoemission, we have the external photo-effect, the absorption of radiation completely removing electrons from a layer. The main infra-red sensitive layer consists of a silver caesium oxide compound surface.[5] It is, of course, this latter effect that is used in the infra-red image converter tube. Image converter tubes relying on an internal photoelectric effect and an electron mirror system[6] will not be considered here, nor will devices such as the image orthicon in which the visible image is not formed in the tube itself.

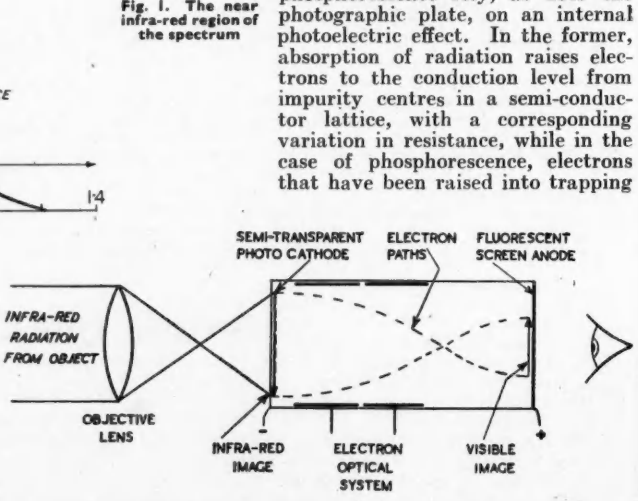


Fig.2. Principle of the image convertertube

* Royal Naval Scientific Service.

Principle of the Image Converter Tube

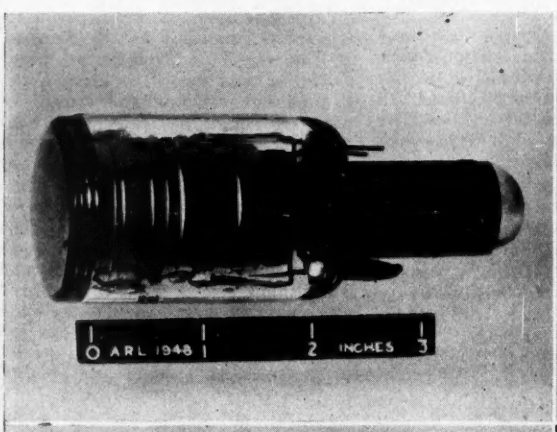
In the infra-red image converter tube, an image formed with radiation of about 1 micron wavelength is transformed into a visible image. The infra-red image is focused on to a Ag-O-Cs photo-cathode and the electrons emitted caused to impinge on an anode in the form of a fluorescent screen. The converter may thus be divided into three main components, the photo-emissive surface, the electron optical system, and the screen, with each of which it is intended to deal briefly here.

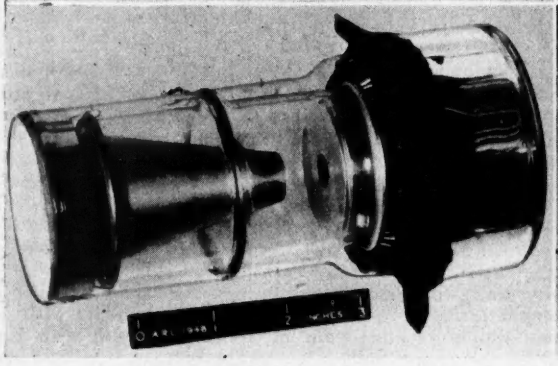
The photo-emissive effect in an Ag-O-Cs layer results from the removal of electrons from the outermost orbits of the caesium atoms by absorption of infra-red radiation. The energy transferred to an electron by a photon is sufficient not only to enable it to leave the field of influence of the parent atom but also, under favourable conditions, to overcome the forces of surface attraction and so leave the layer and pass into the evacuated space outside. The magnitude of the effect is dependent upon the wavelength of the incident radiation, and in the case of the composite caesium surface, peak response occurs at about 8,000 Angstroms with a long wave cut-off at 13,000 Angstroms. The number of photo-electrons is proportional to the intensity of radiation, although at room temperature there is always a number of electrons leaving the surface as a result of thermal agitation. There is some spread in velocity among the photo-electrons corresponding to the different wavelengths (energy) of the exciting radiation and to the varying depths in the layer at which the electrons are released. The high accelerating voltages employed render this spread of velocity unimportant. Since the number of electrons leaving a point of the photo-sensitive surface will be proportional to the intensity of radiation at that point (ignoring the background of thermal electrons), it can be seen that the electron density immediately outside the surface will vary from point to point according to the corresponding variation in the intensity of the infra-red image focused onto the surface. The infra-red image has thus been replaced by an electron image.

The electrons forming this image are accelerated towards the fluorescent screen anode by an applied field of several thousand volts, and, except in the simplest forms of image converter, pass through some form of electron optical system in the process. The high voltage both limits the electron spread during the passage from cathode to anode and also gives a fluorescent image of high brightness. The tendency of electrons to follow helical paths about magnetic lines of force may be utilised to bring all the electrons leaving a point of the cathode to a point focus on the screen irrespective of the original

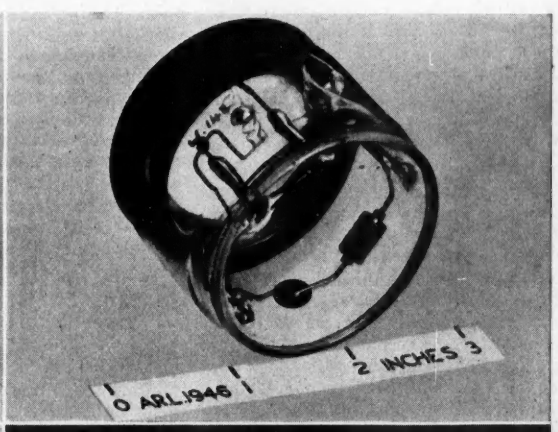
Fig. 3. Types of infra-red image converter

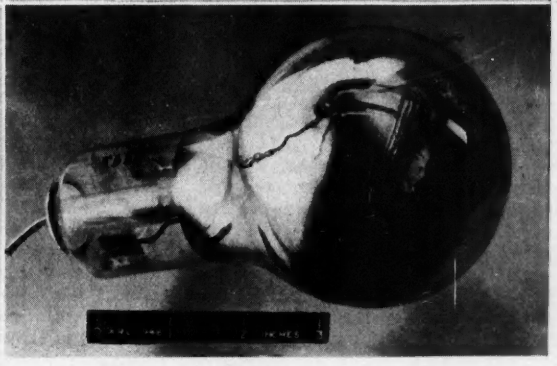
R.C.A. (American)
A.E.G. (German)





E.M.I. Ltd. (British)
Philips (Dutch)





angle of emission of the electrons. Alternatively an electrostatic focusing system may be employed when the inverted infra-red image formed by a normal glass lens on the photocathode may be reproduced as an erect image on the screen, and further the size of the latter image may to some extent be varied. It is an advantage to reduce the size of the fluorescent image and so, by increasing the electron concentration, obtain a brighter image on the screen. An electron optical reduction to about one-half is the optimum. The principles of electron optics and the analogy to normal optics are well known, applications being widespread in both the field of electronics and, for example, electron microscopy. Use is made of the fact that electrons are deflected by an electrostatic field, tending to follow a path at right angles to the equipotential lines. Thus the electron lens formed by the field between two adjacent co-axial cylinders of different potential has a similar focusing effect on a parallel beam of electrons as does a convex glass lens on a parallel beam of light. In the image converter tubes use is made, for the most part, of either cylindrical or aperture electrostatic lenses. Little use has been made of electromagnetic lenses owing to the greater weight of such systems.

After passing through the electron optical system the electrons impinge on the fluorescent screen. Various compounds are available for use as screen material, for example, zinc sulphide and willemite (zinc orthosilicate). The comparative inertness of the latter to caesium contamination makes it particularly suitable, as does the colour (green) which corresponds roughly to the maximum sensitivity of the eye. Bombardment by high velocity electrons will, of course, cause the screen to glow. The intensity of the light emitted by the fluorescent material is proportional to the number of electrons striking it, and thus the variations in brightness from point to point of the fluorescent image will correspond to the variations in electron density in the electron image which, in turn, is directly related to the variations in intensity of the original infra-red-image. The latter has thus been transformed into an image visible to the eye.

Historical Development

The development of the image converter tube may be traced back to the modification of the electron microscope employed, for example, by Brüche[7] in an investigation of metallic surfaces. The state of a surface is, to some extent, reflected in the electron emission under ultra-violet irradiation. Brüche formed an image of a zinc surface in an electron microscope using the electrons emitted by the zinc when illuminated with a mercury arc. Other workers used similar systems and it was a logical development to arrive at a device in which the electrons imaged on the fluorescent screen originated from an infra-red image focussed on a caesium photosurface. In 1934 the first description was published of a normal image converter tube, the principle of which had earlier been advanced in the form of a patent (B.P. 326200) by Holst and his co-workers[8] of Messrs. Philips of Eindhoven. Their arrangement is of particular interest since it was chosen by the Admiralty in 1940 as the basis of the British Service image converter tube. The cylindrical glass envelope of the tube is fitted with two plane parallel windows, on one of which is deposited the photo-cathode, on the other the fluorescent screen. An accelerating potential of a few thousand volts is applied between anode and cathode which are separated by a distance of 2 cm. The photo-electrons emitted are accelerated along a straight path by the homogeneous electrostatic field and impinge on the fluorescent screen giving rise to a visible image bearing a one-to-one correspondence to the original infra-red image falling on the cathode. The definition attainable with such a simple device is limited by the varying angles of emission of the photoelectrons and by the spread due to mutual repulsion during passage to the screen. Coeterier and Teves later introduced improvements to the simple system, and experimented with alternative focusing devices.

Also in 1934, Farnsworth published in America details of a so-called image dissector tube for television purposes.[9] In his tube a plane cathode was used with a uniform electrostatic field, together with a uniform magnetic field produced by a solenoid wound around the outside of the tube. Since electrons travel in helical paths about the magnetic lines of force, all electrons leaving a point of the cathode, whether in a normal direction or not, can be brought to a point focus in the final image plane by means of the magnetic field. It can be shown that the position of this focus is independent of the transverse velocity of the electrons on emission. In the image dissector tube, the whole electron image was deflected by means of additional magnetic coils, so that it fell point by point on the collecting anode after passing through an 0.015 in. aperture. This aperture determined the resolution, and using a 4 in. cathode Farnsworth achieved a 240 line picture. Although developed as the basis of a television camera, in which application an electron multiplier was added to the anode, in order to examine the quality of the electron image the collecting anode may be replaced by a fluorescent screen, when the system corresponds to that of Holst with the addition of a long magnetic lens.

The focusing effect of the long magnetic lens and the consequent improvement of definition led Coeterier and Teves to modify the Philips tube to include a uniform magnetic field.[10] They also constructed tubes in which use was made of a converging field that permitted an electron optical reduction in image size. The improvement in definition resulting from the employment of focusing systems was calculated by Henneberg and Recknagel of A.E.G.[11] Three systems were considered, the uniform electrostatic field, the electrostatic field with uniform magnetic field added, and a short lens. Calculated circles of confusion in the three cases were:

$$4l\sqrt{\frac{E}{U}} \; ; \; \frac{2lE}{U} \; ; \; \frac{2L}{(2V+1)}\frac{V}{U}\frac{E}{U},$$

where l is the anode-cathode spacing, E, the velocity of emission of the photo-electrons, and U, the final velocity of the electrons. In the third formula V is the magnification, and L the cathode-lens centre spacing. With a factor E/U of the order of 10^{-4} a resolution of 250 lines per in. (black plus white) might be expected from the simple electrostatic arrangement with a gain of about 100 times with the

magnetic field. In practice E.M.I., Ltd., achieved a better figure and Coeterier and Teves with the long magnetic lens reported a resolving power many times better than with the simple system. In general, the theoretical gains with lens systems have not been obtained.

Tubes employing more complex electron optical arrangements were soon investigated. Pohl[12] first described the use of a short lens between cathode and anode. Heimann[13] of the German Post Office Laboratory developed a tube employing both magnetic and electrostatic focusing, the latter being carried out by two metal cylinders at different potentials. The electrostatic lens inverted and reversed the fluorescent image relative to the infra-red image on the photocathode so that the orientation of the final image corresponds to that of the object. Schaffernicht[14] also produced a tube with combined electrostatic and magnetic lenses resulting in an electron optical reduction in image size, whereas Heimann's tube gave a magnified fluorescent image. The opaque cathode was deposited on a concave surface and the shape on the anode cylinder was such that a suitable focusing effect was produced with a single applied voltage. Movement of the magnetic lens enabled the magnification to be varied. Cathode-anode spacing was 40 cm. and accelerating potentials up to 20,000 volts were applied. The original tube was not, in fact, an infra-red image converter, but employed an ultra-violet sensitive potassium photo-surface. Von Ardenne[15] describes a similar arrangement in which the cylindrical electrostatic lens incorporated a resistance element in the form of a fine nickel spiral. It was claimed that the system resulted in reduced field emission owing to the lower potential gradient in the vicinity of the cathode.

Early RCA Tubes

In America, Zworykin and Morton,[16] of R.C.A., reported on optical systems for image converter tubes using only electrostatic focusing. A curved cathode was used in conjunction with a series of focusing rings giving a compromise between the resistance lens and the single element (Fig. 4). Introduction of an aperture between lens system and anode enabled the magnification to be varied. Morton and Ramberg[17] extended the investigations of this type of system using moveable anode and cathode. The R.C.A. team also described a tube employing a uniform electrostatic field and a long magnetic lens.[18]

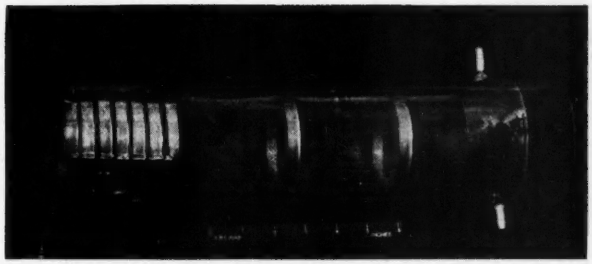


Fig. 4. Early R.C.A. tube with electostatic focusing.

Continuing their work on image converters, Coeterier and Teves[19] developed a tube that could be used conveniently with an opaque photocathode and fluorescent screen. Use was made of a magnetic field to deflect the electrons through a right-angle. The radiation passed through the wall of a spherical glass bulb before falling on the cathode on the back wall of the bulb. The anode was mounted in the neck of the bulb at right angles to the cathode, both anode and cathode having a cylindrical magnet behind them. An accelerating potential up to 10,000 volts was applied. An alternative arrangement was also used in which the positions of anode and cathode were reversed and a third electrode added in the form of a ring spaced a short distance from the cathode. The accelerating voltage was applied between ring and cathode so that the deflecting and focusing action took place in a region free from any disturbing electrostatic field. A further development consisted of a double system in which the first anode consisted of a caesium treated plate, the secondary electrons from which were in turn focused on a fluorescent screen.

In 1938, E.M.I., Ltd., produced a system employing a plane parallel cathode and anode with a long magnetic lens, either in the form of a solenoid or a permanent magnet. Multiplication stages consisting of caesium-coated grids were introduced between cathode and anode. This resulted in a substantial improvement in sensitivity at the expense of resolution. It thus came about that, at the outbreak of war, some form of image converter tube was available in this country, in America, in Holland, and in Germany.

War-Time Development

Consideration of the military applications of infra-red image converter tubes was commenced by the Admiralty in 1938. It soon became apparent that the devices already available were too cumbersome for many of the possible Service uses, although technically the performance was promising. In addition, production techniques were difficult. After comparative tests of the available British, American and Dutch gear in 1940, it was decided that if useful quantities of equipment were to be available for Service use in an acceptable time, the original system of Holst offered the best possibilities. The Philips team had given a number of reasons why the simple arrangement was undesirable—for example, the difficulty of working at high voltages with a small cathode-anode spacing, optical retroaction between fluorescent anode and the cathode, and the relatively low sensitivity of semi-transparent photo-surfaces, but it was considered that simplicity justified a fuller investigation. Accordingly E.M.I. were asked to undertake the development of a tube based on the original Holst design. When the complexity of the Super-Emitron television camera is compared with the simplicity of the image converter, it is perhaps not surprising that within a month or two Dr. J. D. McGee, of E.M.I., was able to demonstrate a successful tube of the simple type. Development and improvement followed rapidly and this tube, which was produced in quantity by the Gramophone Co. and later also by Lines Bros., became the basis of many thousands of infra-red receivers that were manufactured between 1942 and 1945.

E.M.I. Tube

The final arrangement of the tube

is shown in the photograph of Fig. 3. The cylindrical Pyrex envelope, 5 cm. in diameter and 4 cm. in length, is fitted with plane end windows 2 mm. in thickness. On the inside surface of one of these is deposited the semi-transparent Ag-O-Cs layer, while the screen is mounted at a distance of 5 mm. from the photo-surface. The willemite is deposited on a thin glass disk on which a platinum graticule has been sputtered to reduce screen resistance. The screen mounting is carried on tungsten wire supports sealed into the second window through which the fluorescent image is viewed. Cathode contact is made by a platinum paste seal at the edge of the window. To prevent caesium contamination of the willemite and to facilitate the deposition of a uniform photo-surface, during the activation processes the screen lies with willemite surface downwards on the back window of the tube. Evaporation of both silver and caesium is carried out by electrical heating of small evaporators inside the tube itself. Otherwise the processes employed are similar to those normally used in the preparation of this type of layer. Care in design and manufacture resulted in a high level of insulation being maintained and potentials of between 3,000 and 7,000 volts can be applied to the tube without failure. The deposition of the cathode on a plane glass surface without any associated metal parts helps in this respect by reducing cold emission. The final sensitivity of the semi-transparent photo-cathodes was comparable with the values normally obtained for opaque surfaces of the same material.

RCA Tube

Both the American and German tubes developed for military applications employed electrostatic focusing. The R.C.A. tube has been described by Morton and Flory.[20] Use is made of a four-component cylindrical lens in conjunction with a curved cathode, the actual curvature of the latter being a compromise between light and electron optical considerations. The introduction of low potential components between cathode and main lens enables a sufficiently flat image plane to be obtained. The electron optical magnification is ½, which represents the best compromise between the brightness of the fluorescent image and the power and exit pupil of the viewing lens required. Accelerating potential is 4,000-5,000 volts. The overall dimensions of the tube are 11 cm. length and 4 cm. diameter.

AEG Tube

The production version of the A.E.G. tube manufactured for the German forces used an aperture lens requiring a single intermediate potential. Again image distortion was reduced by using a curved cathode and electron optical magnification was about ½. A high voltage was applied to the tube (up to 17,000 volts) and the image brightness was further enhanced by the application of an aluminium layer to the back of the screen. Overall dimensions were 8 cm. by 16 cm., although a smaller version was commencing production at the end of the war. The photographs of Fig. 3 show the development of the various tubes as a result of the military requirements and the relative sizes can be judged from the scales. The simplicity of the British tube resulted in it being the first to become available in production quantities, whereas in the case of the A.E.G. tube, in spite of very much greater development effort, Service equipment had only reached the training stage in the German army at the end of the war.

Although the E.M.I. tube represents the best compromise between performance and complexity in the applications for which it was originally intended, namely the detection of sources such as infra-red homing beacons, the more complex focusing systems are an advantage where extended images are involved. Some gain in resolving power is possible, using a lens system, but operationally the more important advantage is the higher brightness level of the fluorescent image. The electron optical reduction combined with a high power viewing lens is partly responsible for this gain. In addition, the larger cathode-anode separation enables higher accelerating voltages to be used as in the case of the A.E.G. tube. Comparative resolving powers of the British and German tubes are shown in Fig. 5. The uniform resolution over the whole screen of the former is apparent as is the high resolution at the centre of the screen in the case of the latter. Exposure time in photographing the screen of the British tube was several times that required for the A.E.G. tube.

(To be concluded)

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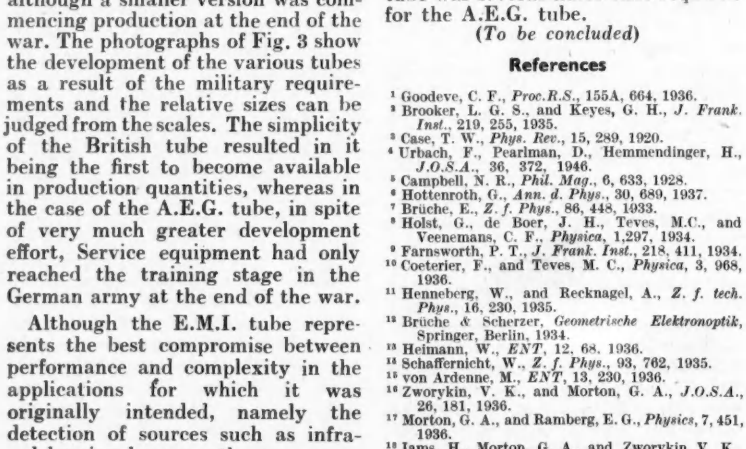


Fig. 5. Comparison of definition of E.M.I. (left) and (right) A.E.G. tubes

The Miller Integrator

PART 2.—Non-linearity, and some Practical Circuits.

By B. H. BRIGGS, M.A.*

The second of a series of three articles dealing with the basic theory of the Miller Integrator and its application to circuit technique. The properties of this circuit were first investigated by the late A. D. Blumlein, and it has been suggested that the term "Blumlein Integrator" is more appropriate, but the name "Miller Integrator" is now firmly established owing to its derivation from the Miller Effect.

IN the previous part of this article the basic principles of the Miller Integrator were described, with particular reference to the production of a potential variation which is linear with time. In this part it is first proposed to discuss the exent of the departures from linearity which may be expected with this type of circuit.

Non-linearity is due to the fact that the grid potential changes during the run-down, the amplifier gain being finite. Thus, the current in the grid leak R is not exactly constant and the Miller capacitor C is not discharged at a constant rate. In order to calculate the magnitude of the effect it is only necessary to determine the change of grid potential which occurs, and the method of successive approximation may be used.

Let $\bar{g}_m$ be the mean slope of the valve over the range v_1 to v_2, where v_1 is the instantaneous grid potential at the start of the run-down, and v_2 the instantaneous grid potential at the end of the run-down. The rate of change of anode potential initially is $(V - v_1)/CR$, and at the end of the run-down it has decreased to $(V - v_2)/CR$.

The total change of rate is therefore $(v_1 - v_2)/CR$. If the anode potential falls from H.T. potential to earth, the anode current change is V_b/R_L.

Thus $\bar{g}_m(v_1 - v_2) = V_b/R_L$.

Thus change of rate

$$= \frac{V_b}{\bar{g}_m CRR_L} \text{ volts/sec.} \quad \ldots\ldots (11)$$

As the mean rate is approximately V/CR volts/sec., it follows that the fractional change in rate is:

$$\frac{V_b}{V} \cdot \frac{1}{\bar{g}_m R_L} \quad \ldots\ldots (12)$$

The same result holds if V_b represents the total anode voltage change, even if this is not equal to the H.T. voltage.

From (12) it will be seen that for good linearity $\bar{g}_m$ and R_L should be as large as possible. The permissible value of R_L is limited by the flash-back time constant (values as high as ½M are common). For given time base speed V/CR will be constant; from the point of view of linearity, it is advantageous to use a high value of V, and choose CR accordingly.

In a typical case we may have $V_b = 300$ v., $V = 100$ v., $\bar{g}_m = 5$ mA/volt, $R = 200{,}000$ ohms. This gives a change of rate of 0.3 per cent.

SYMBOLS USED

A	D.C. Amplification $= g_m R_L$
C	Value of "Miller" Capacitance from anode to grid
g_m	Slope of valve in A/V.
$I_a, I_{g1}, I_k, I_L, I_R, I_{g2}$	: See Fig. 3
R	Value of "Miller" resistance (grid leak)
R_L	Anode load resistance
t	Time
T_1	Total duration of "run-down," or time base length in secs.
V	Voltage applied to grid leak R
V'	$=(V+V_0)$=the corrected value of V to allow for the fact that the mean grid potential is negative with respect to earth by an amount V_0.
V_a	Anode potential, or output voltage
V_b	H.T. potential
V_c	Cut-off bias
V_{g1}	Control-grid potential
V_{g2}	Screen-grid potential
V_{g3}	Suppressor-grid potential

Additional Symbols not used in Pt.I

V'_b	Fixed positive potential, less than V_b to which the cathode of the anode-catching diode is connected.
V_1, V_2	Instantaneous grid potentials at the beginning and end of the run-down, respectively.
I_m	Maximum anode current which the valve can pass without grid current, at the given value of screen-grid potential.
k	Rate of change of anode potential during the linear run-down. $=V'/CR$ volts per second.
Z_L	General impedance used as anode load of the Miller valve.

Other symbols not given in this list are explained in the text when first used.

To determine the actual law of the run-down when grid motion is allowed for, we assume as a first approximation

$$V_a = V_b - kt \quad \ldots\ldots (13)$$

where $k = V'/CR$.

This requires a grid potential variation given by

$$V_{g1} = \frac{kt}{g_m R_L} + v_1$$

A better approximation to the current in R is therefore

$$\left(V - \frac{kt}{g_m R_L} - V_1\right)\frac{1}{R} = \frac{V'}{R} - \frac{kt}{g_m RR_L}$$

As this is equal to the current in C

$$C\frac{dV_a}{dt} = -\frac{V'}{R} + \frac{kt}{g_m RR_L}$$

and a second approximation to the anode potential is

$$V_a = V_b - kt + \tfrac{1}{2} \cdot \frac{k^2t^2}{g_m R_L V'} \quad \ldots\ldots (14)$$

The same result can be obtained from a rigorous analysis based on Equation (1), in which case the term in t^2 appears as the second term of an expansion in ascending powers of t. It is rarely necessary to carry the expansion beyond this term, especially in view of that fact that the analysis is based on the assumption of linear valve characteristics. The rigorous result[1] includes, of course, terms of the type $A/(1+A)$, and is, in fact,

$$V_a = V_b - \left(\frac{A}{1+A}\right)kt + \tfrac{1}{2} \cdot \frac{A^2}{(1+A)^2} \cdot \frac{k^2t^2}{g_m R_L V'} \quad \ldots\ldots (14)$$

Alternative Types of Anode Load

A Miller valve is very often used with some impedance Z_L, other than a pure resistance, as the anode load. This may be unavoidable, as for example, when the anode load consists of a resistance in parallel with the total stray capacities from anode to earth. Or, it may be deliberate, as when an inductive anode load, or a tuned circuit, is used for some special purpose. In order to see the effect of such anode loads, the method of successive approximation may again be employed. It is clear

* Cavendish Laboratory, Cambridge

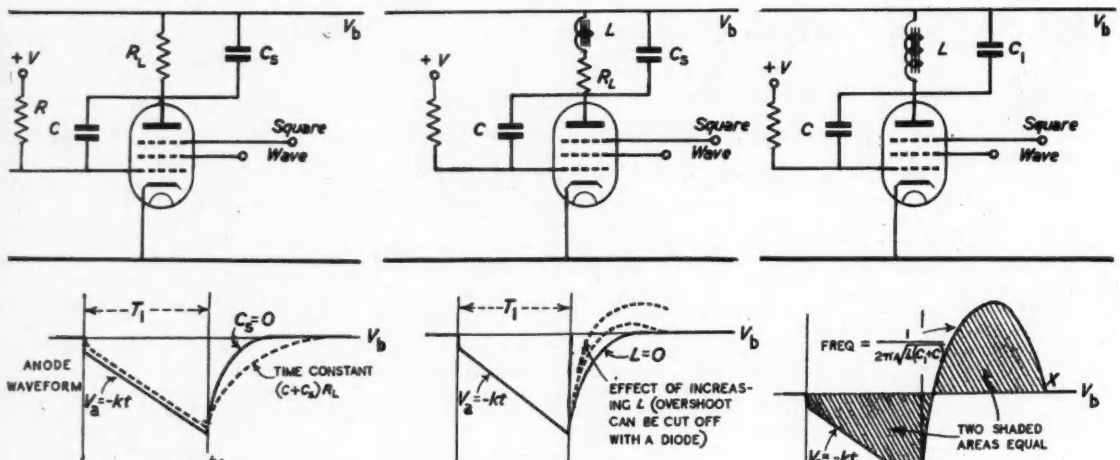


Fig. 7. Miller valve with various types of anode load

that, to a first approximation, the same linear run-down at the anode will take place whatever the anode load; this is required by virtue of the feedback, which will automatically ensure that the grid waveform is such as to give this anode motion. The difference will be that the *current* in the anode load will vary differently with time, giving a non-linear grid waveform, even with linear valve characteristics.

The procedure in designing circuits of this type is therefore as follows:

(1) Assume the anode potential variation $V_a = -kt$, to give the desired time base, and find the current in the anode load as a function of time.

(2) From valve characteristics plot the grid waveform, using the known anode current waveform.

(3) Check that grid current never flows.

(4) Check that the linearity is adequate, by expressing the total change of grid potential as a fraction of V. This gives the fractional change in rate between the beginning and end of the run-down.

Condition (3) puts some limitations on component values or time base speeds which are possible.

It may be noted in passing that a similar procedure can be used to determine the effect of any load impedance which may be connected across the output terminals of the circuit.

Fig. 7 shows three important types of anode load which will now be considered. Suppressor switching is shown, but the results are applicable to other switching methods, except for slight differences in the initial transients.

(a) Z_L Consisting of Resistance and Capacity in Parallel

The capacity, C_s, in parallel with R_L (Fig. 7a), may represent anode to earth capacity of the valve, together with the input capacity of any load, such as C.R.T. deflector plates, or a following valve, which may be connected to the anode. Such capacity is a very important factor in design, and sets an upper limit to the possible rate of sweep of the time base.

The effect of C_s is to demand an additional *constant* anode current during the run-down, the total anode current being

$$I_a = kC + \frac{kt}{R_L} + kC_s \quad \ldots\ldots\ldots \quad (15)$$

Therefore, the grid potential is higher by a constant amount, and the initial drop is reduced. The latter also becomes rounded, and merges gradually into the linear run-down. The *change* of grid

potential during the run-down, and so the linearity, will be unaffected. This assumes that the valve slope is constant at all currents. Actually, the slope increases with increasing current, so that we have the rather surprising result that the presence of C_s may actually improve the linearity. As C_s, or k, is increased, grid current will eventually flow at the end of the run-down. Let I_m be the maximum anode current which the valve can supply without grid current. Then the maximum permissible value of C_s for a given time-base rate k and length T_1 is given by

$$I_m = kC + \frac{kT_1}{R_L} + k(C_s)_{max}$$

$$\text{or } (C_s)_{max} = \frac{I_m}{k} - \frac{T_1}{R_L} - C \quad \ldots (16)$$

Conversely, if C_s is given, (16) will give the maximum time-base speed. I_m depends, of course, on the screen grid voltage, but if the latter is increased in order to increase I_m, a final limitation in the form of screen grid dissipation is eventually reached, depending, however, on the mark-to-space ratio and the method of switching, as noted previously. C_s slows down the flashback, the time constant of which becomes $(C + C_s)R_L$.

(b) Z_L Consisting of Resistance and Inductance in Series

The inductance in this circuit (Fig. 7b) is usually inserted either to improve the linearity, or to speed up the flashback. It is always iron-cored and of many henries inductance and should not be confused with the small compensating inductance used to improve the high frequency response of an amplifier. C_s is still included in Fig. 7b for the sake of generality.

The anode current in this case is easily shown, by solution of the appropriate differential equation, to be

$$I_a = kC + kC_s + \frac{kt}{R_L} - \frac{kL}{R_L^2}\left(1 - \exp.(-R_L t/L)\right) \quad \ldots (17)$$

The first three terms give the anode current when $L = 0$, and the last term shows that the presence of L *decreases* the anode current, thus improving the linearity. From the given anode current variation the initial and final grid potentials v_1 and v_2 can be found from the valve characteristics, so the linearity can be determined. The full effect of L will be obtained only if the fourth term of (17) continues to grow for the whole period of the sweep, *i.e.*, if $L >> R_L T_1$. The flashback overswings above the potential V_b, owing to the presence of the damped oscillatory circuit formed by L, R_L, and $C + C_s$. Although the natural period of this circuit increases as L increases, it is not difficult to see that the flashback actually crosses the V_b line earlier the larger L. Thus, if the overshoot is cut off with a diode (*see* Anode-catching Diode) an improvement in flashback time will have been obtained by the use of L.

(c) Z_L Consisting of Inductance and Capacity in Parallel

The condenser C_1 in parallel with L (Fig. 7c) is now inserted deliberately, in order to form a tuned circuit of known resonant frequency. The anode current during the run-down is

$$I_a = kC + kC_1 + \tfrac{1}{2}\frac{kt^2}{L} \quad \ldots (18)$$

For a given time base speed and length, the value of inductance required will be determined by grid current flow, as explained previously. Equation 18 shows that the minimum is given by

$$L_{min} = \frac{kT_1^2}{2(I_m - kC - kC_1)} \quad \ldots (19)$$

from which it will be seen that the inductance required increases as the square of the time base duration.

The chief point of interest in this case is the flashback waveform. With the simple circuit shown, the anode potential would oscillate continuously about the potential V_b, when the valve is cut off, with frequency

$$f = \frac{1}{2\pi\sqrt{L(C + C_1)}}$$

It is possible to arrange an auxiliary circuit to "clamp" the waveform at the point X, where it recrosses the V_b line. The result is the waveform shown, the important point being that the two shaded areas are equal, because in the continuously operating circuit there can be no mean D.C. voltage across the inductance. Such a waveform can be passed through a transformer without loss of zero-level, and is called a "balanced" time base waveform. This property is used in the magslip method of producing a P.P.I.* type radar display. A complete circuit for the production of such a waveform is given later, but for full details of the magslip method, Reference (2) should be consulted.

* Plan-position-Indicator ; a radial time base rotating in synchronism with the aerial system.

Output Impedance during the Run-down

To find the output impedance, consider the effect of impressing on the anode a small sinusoidal voltage V_a by means of an external generator. The voltage appearing at the grid will be

$$V_{g1} = \frac{R}{R - j/\omega C} V_a$$

and this will produce an anode current

$$I_a = g_m V_g = \frac{gR}{R - j/\omega C} \cdot V_a$$

Thus, to an external source, the valve appears as an impedance

$$\frac{R - j/\omega C}{g_m R} \quad \ldots (20)$$

i.e., a condenser CRg_m in series with a resistance $1/g_m$. The total output impedance consists of this combination in parallel with Z_L (Fig. 8). (This result is sometimes used to produce a large capacitor, as Rg_m may be of the order of several thousand)

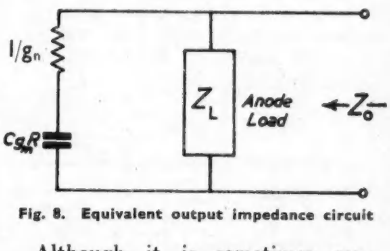


Fig. 8. Equivalent output impedance circuit

Although it is sometimes convenient to work with the actual value of the output impedance, it is usually preferable, in considering the effect of some load on the circuit, to use the method indicated earlier, *i.e.*, to calculate the current required from the valve to produce the waveform across the load. This method has the advantage that it gives the overload point (the point at which grid current flows); this obviously cannot be obtained by considering the output impedance alone.

Use of an Anode-Catching Diode

The exponential flashback obtained with the usual resistive anode load, is of a very uneconomical shape. In order to improve the situation, a diode is often used as shown in Fig. 9 The cathode of the diode is connected to a fixed positive

potential, V_b', less than V_b. Instead of the exponential ABC', we now follow curve ABC, as the anode is prevented from rising appreciably above V_b by current flow in the diode. When a steady state is reached, there will be a constant current flowing in the diode of amount $(V_b - V_b')/R_L$.

It will be seen that in this way a considerable reduction in the flashback time has been achieved, with but little reduction in the available output amplitude. The succeeding sweep can start immediately after the point B. This use of an anode-catching diode is very common; V_b' is often made variable to act as an amplitude control. The initial drop with suppressor switching occurs as before, but is reduced in magnitude, because the anode current immediately after the drop is greater, being approximately equal to

$$\frac{V_b - V_b'}{R_L} + \frac{V'}{R}.$$

Equivalent Circuits; Miller Effect

With a resistive anode load, an equivalent circuit is obtained by replacing the condenser C from grid to anode by a condenser $C(1 + A)$ from grid to earth, where A is the gain of the valve (Fig. 10). This is the well known "Miller Effect," from which the circuit derives its name. The linear run-down can now be regarded as the initial part of the exponential charge of the condenser through R, amplified by the valve, *i.e.*,

$$V_a = -AV_{g1}$$
$$= A[1 - \exp.(-t/(1 + A)CR)]V$$

If this is expanded in powers of t it will be found to agree essentially with Equation (14'). The exponential anode waveform is the same as would be produced by the circuit of Fig. 10b. As the value of A may be of the order of 500, the linearity is the same as if the capacitor in the simple CR circuit were charged from a voltage of the order of 10,000 volts, only the first 300 volts of the exponential being used.

It should be emphasised that these equivalent circuits obscure the advantages which the original circuit possesses, by virtue of its being a feedback circuit. Thus, in Fig. 10 the output waveform would be influenced by any lack of linearity in the valve characteristics, and by stray capacities from anode to earth. Moreover, the exact rate of sweep of the time base would depend on the gain of the valve. This cannot be regarded as a quantity which is known with any precision, owing to variations of g_m with cathode current, and from valve to valve.

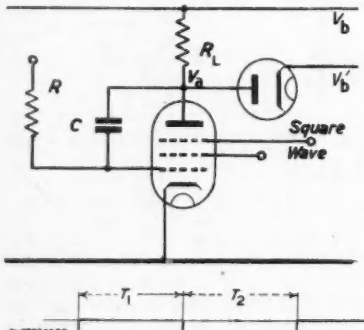
This completes the discussion of the basic principles of the Miller integrator, and the rest of this article will be concerned with examples of practical circuits in which these principles are applied.

Single Valve Self-Running Time Base

The simplest self-operating circuit for use as a time base is shown in Fig. 11. The self-running action is obtained by the well-known "Transitron" connexion, between screen and suppressor grids.[3] As the operation is described it will be seen that this is an example of "Suppressor-Switching."

During the period BC, the valve is performing the usual Miller run-down, the suppressor being at earth potential. At C the anode bottoms, causing an increase of screen current, and so a simultaneous drop in potential of screen and suppressor grids. When the suppressor reaches cut-off, anode current begins to decrease, causing a still further increase in screen current. There is thus a cumulative effect, anode current is completely cut off, and the suppressor falls well below cut-off (say, to −150 V). At the same time there is an increase in space current (all of which flows to the screen grid) because the grid is pulled positive by the anode via C, as the anode begins an exponential recovery CE to V_b with time constant CR_L. Simultaneously with the anode, the suppressor begins an exponential recovery DF of time constant C_1R_1 to earth potential. The values are arranged so that the anode is caught at potential V_b' by the diode D_1 before the suppressor recrosses the cut-off line. At F the suppressor reaches cut-off, and anode current begins to flow again, thus initiating the reverse transitron action. (Screen current decreases, screen potential rises, raising the suppressor via C_1; screen and suppressor go positive together). The suppressor is caught at earth potential by the diode D_2. The anode performs the initial drop FG, followed by the linear run-down GH. One complete cycle has now been described and it is clear that the action is self-maintaining.

Synchronisation is best applied to the suppressor circuit where it will determine the exact point F at which the run-down is initiated. The use of the anode-catching diode has the advantage that the synchronisation does not affect the amplitude



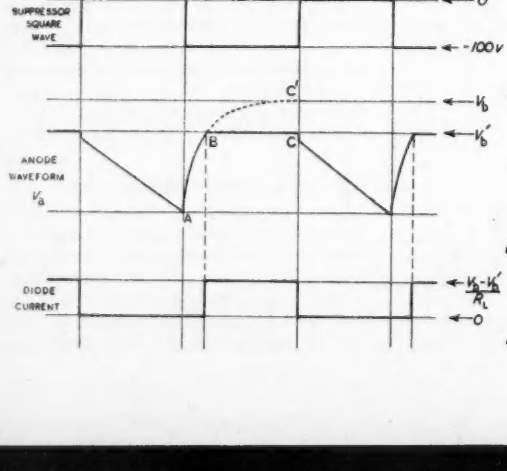
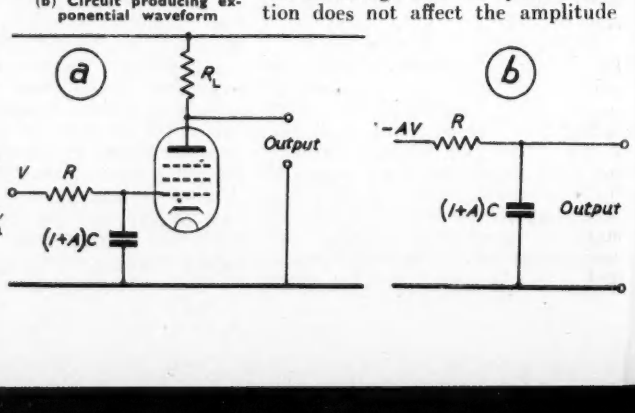


Fig. 9. Anode-catching diode circuit with appropriate waveforms

Fig. 10. Equivalent circuits (a) Miller effect with resistive anode load. (b) Circuit producing exponential waveform



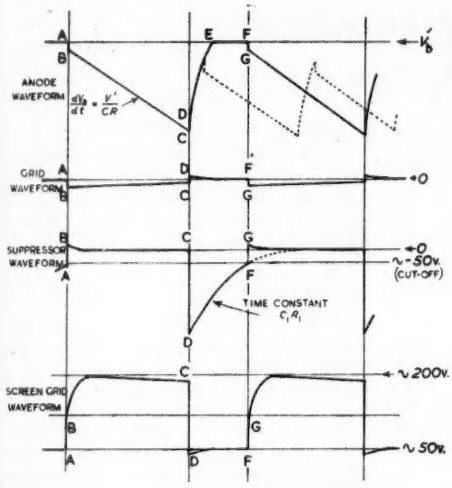


Fig. 11. Transitron-Miller self-running time base. Suggested values for an EF. 50 valve to give sweep frequencies from 3 c/s to 100 Kc./s are :

C: 1 μF. .013 μF. 1600 pF. 200 pF. 25 pF.

C_1: 5 μF. .05 μF. 005 μF. 1000 pF. 100 pF.

R:200 KΩ in series with 2 MΩ variable.

R_L : 50 K Ω R_1 : 100 K Ω R_2 : 40 K. D_1 is omitted

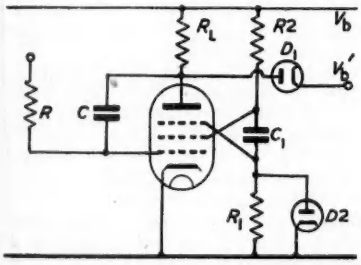


Fig. 12. Circuit for producing balanced time-base, and appropriate waveforms

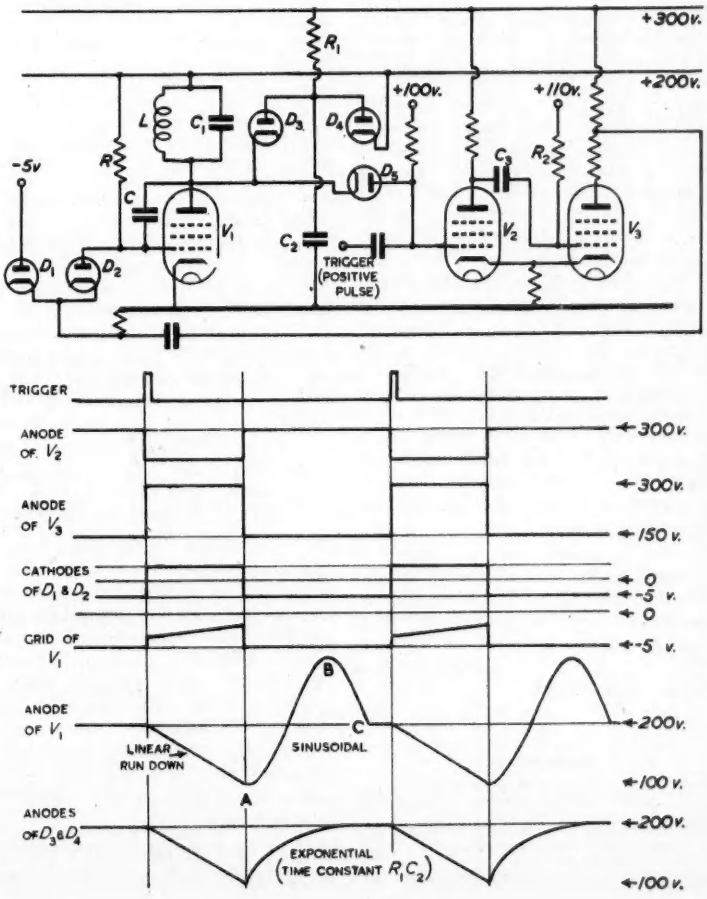
of the waveform, but only alters the length of the period *EF*. However, the latter represents a wasted period, which may be undesirable. If the speed of the suppressor recovery *DF* is increased by reducing R_1, a condition will be reached in which the next sweep begins before the anode recovery *CE* is complete (as shown by the dotted anode waveform), so that the wasted period is eliminated. This is another common mode of operation, the anode-catching diode being omitted. If the suppressor is allowed to go positive, trouble may be experienced due to suppressor current flowing, and for this reason the diode D_2 is included. It may be omitted if simplicity is the first consideration.

Time-base speed may be varied by V or R, and the amplitude by variation of V_b', or by making R_L a potentiometer. To cover a wide range it will be necessary to switch C and C_1 together. The screen waveform, after squaring up, is suitable for use as a black-out waveform.

In spite of its simplicity, this circuit possesses all the advantages associated with the Miller principle, and has much to recommend it for general use as a self-running time base. Where the highest reliability is required, however, the Transitron principle has come into disfavour, as it is somewhat sensitive to individual valve characteristics.

Circuit for the Production of a "Balanced" Time Base Waveform

This is an instructive circuit using a Miller integrator with a tuned circuit as anode load, and grid-switching. Both of these features have already been described; it remains only to explain the operation of the rest of the circuit, which is shown in Fig. 12. The valves V_2 and V_3 form a cathode coupled flip-flop, in which C_3R_2 is a long time-constant relative to the repetition period. The steady state condition of the flip-flop is with V_3 conducting and V_2 cut-off, because V_3 has a grid leak returned to +110 volts, whereas the grid leak of V_2 is returned to +100 volts. The circuit



is triggered by means of a positive pulse applied to the grid of V_2; this flips the V_2V_3 circuit into its alternative state, with V_2 conducting and V_3 cut-off. The anode of V_3 delivers a square wave which is used to perform the desired grid-switching of the Miller valve V_1. The run-down at V_1 anode therefore starts on receipt of the triggering pulse; it continues until the anode falls to +100 volts, when the diode D_5 conducts thus "resetting" the flip-flop to its initial state. The circuit then remains quiescent until the next triggering pulse.

The details of the "clamping" of the flashback waveform must now be explained. This function is performed by the diodes D_3 and D_4. At the end of the run-down the current in the tuned circuit LC_1 is suddenly cut-off, and a sinusoidal ring is produced (*ABC* in Fig. 12). During the run-down the anode of D_3 follows that of V_1, but during the flashback it is "left behind" and D_3 ceases to conduct. This occurs because the time constant R_1C_2 is arranged to be so long that the anode of D_3 can only rise more slowly than that of V_1. However, during the period *ABC*, C_2 will charge up through R_1 and will eventually be caught at +200 V by D_4, any further charge being prevented. It is arranged that this occurs during the period *BC*. When the anode of V_1 swings back to 200 volts from above, D_3 conducts (because its anode is now at 200 volts) and, provided that the current in R_1 is large enough to keep D_3 conducting, the anode of V_1 will be unable to fall below 200 V. Thus the sinusoidal ring is damped out, and the anode of V_1 remains clamped at 200 volts until the next triggering pulse.

The waveform at V_1 anode is automatically "balanced" about the 200 volt H.T. line owing to the fact that there can be no mean D.C. voltage across a pure inductance. The use of such a waveform was mentioned earlier.

(*To be continued*)

References

[1] F. C. Williams and N. F. Moody "Ranging Circuits, Linear Time Base Generators and Associated Circuits." *J.I.E.E.* Part III A, No. 7.

[2] F. C. Williams, W. D. Howell, and B. H. Briggs, "Plan-Position Indicator Circuits" *J.I.E.E.*, Part III A, No. 7.

[3] O. S. Puckle, "Time Bases" Chapman and Hall.

The Transistor

A Crystal Valve Amplifier

THE announcement of the development of the Transistor, a germanium valve amplifier developed by Drs. Bardeen and Brattin, of the Bell Laboratories*, has been followed by a preliminary note on the design of an experimental amplifier by Winston Wells in the July issue of *Audio Engineering*.†

A two-stage amplifier based on the Bell Laboratories design data contains two crystal valves, each consisting of a germanium crystal on which are placed two contacts 0.001 in. diameter and 0.002 in. apart. The input, or "grid" contact has 1 V positive bias applied between it and the common electrode of the crystal, and the output or "anode" contact is biased negatively to 40 V. The crystals are coupled by transformers having the correct step-down impedance ratio (see on).

The action of the germanium crystal amplifier is explained by W. Wells as follows:

In the particular crystal used, a small amount of tin impurity is present in the germanium which affects the conductivity by providing extra electrons. Between the inner and outer electron shells of the germanium atom there exists a zone whose force fields do not permit the existence of orbital electrons under normal conditions. The proximity of the tin atom distorts these force fields, allowing four electrons from the "O" shell of the tin atom to circulate in the "forbidden" shell of the germanium atom.

These borrowed electrons require a higher potential difference between the contact and the crystal for their release, and when the contact is made sufficiently positive the orbits of these electrons expand, allowing them to come into the outer zone where conductivity takes place. Conversely, a negative potential at the contact reduces the orbits of the borrowed electrons and hence the conductivity.

A fairly high potential is required to maintain the current flow between a negatively charged contact point and the crystal, since the borrowed electrons will be pushed down below the zone of activity and only the outer electrons of the germanium atoms will be participating.

If, however, a second contact is introduced in close proximity to the first and positively charged, the borrowed electrons will again be elevated to the active region, releasing about twice as many for participation in conduction.

These newly released electrons may take part in the conductivity of the "anode" circuit, as well as the "grid" circuit, and their effect is thus to modulate the current flow in the "anode circuit."

It is apparent that the grid current may have to equal or possibly exceed the anode current in order that this effect may take place, but power amplification takes place due to the fact that the grid voltage is many times smaller than the anode voltage. As an example, the germanium valve may require a grid current change of 4 mA to effect an anode current change of 1.4 mA, but the impedance ratios are such that a change of 0.3 V on the grid would produce a change of 1.5 V in the anode circuit. Thus an input signal of 3 mW would give an output of 60 mW.

In the design of an amplifier, it is obvious that amplification can only take place when E_gI_g/E_aI_a is less than unity. Circuit efficiency can be gained in two ways: by making the electronic paths of the anode and grid contacts through the crystal as nearly coincident as possible, consistent with low cross-current flow between contacts, and by using the optimum step-down impedance ratio between the anode circuit of one stage and the grid circuit of the next. These factors are inter-related and may be expressed by the formula:

$$Z_gZ_a/I_g^2I_a^2$$

* *Phys Rev.* July 15, 1948.

† *Audio Engineering*, July, 1948, p. 6.

POWER DIODES

Part 2. The Rating of High-Vacuum Oxide-coated Rectifiers

By E. G. ROWE, M.Sc., M.I.E.E., D.I.C.* R. E. B. WYKE, A.M.I.E.E.* W. MACRAE, M.Sc., A.M.I.E.E.*

AN immense variety of electrical equipment requires the supply of direct current. The method of obtaining this from an alternating current source by means of thermionic valves is one which used to be confined mainly to radio sets, but in recent years it has become popular in a wide variety of applications because of its compactness, freedom from moving parts and its economy. Applications which quickly come to mind are radio and television receivers, public address and relay amplifiers, transmitters, communication power packs and test equipment.

The form of direct current supply demanded can vary from the raw pulsating variety obtained from a single-phase half-wave unsmoothed circuit to one having a smoothness approaching that of battery D.C.

Each application has its own technical and economic requirements for freedom from ripple voltage and each need can be satisfactorily met by the suitable choice of circuit and filter design.

The use of rectifying valves in radio receivers has given little cause for complaint from the viewpoint of the valve manufacturer because the circuits in use have been extremely orthodox and the economic requirements of radio sets have ensured that transformer ratings would not impose exacting conditions on the valve. The main problems have occurred in cases where the valves used have been operated above their rating, either on current or on reservoir capacitor value.

In large amplifiers it has been found generally that reasonable design safety factors have been allowed, but troubles have occurred due to overheating by mounting rectifying valves and large output valves close together without adequate ventilation.

The design of rectifying equipment for the anode supplies of large transmitters has also given very few problems because these circuits have been properly rated and each application is an individual one which can be analysed on its own particular merits.

* M.O. Valve Co., Ltd.

TABLE I—Types of Circuit

Type	Uses	Remarks
1. Single-Phase Half-Wave	1. A.C./D.C. radio sets 2. Low current supplies where little smoothing needed (*i.e.*, grid bias) 3. Low current, high voltage (cable testing, etc.)	Fairly cheap to install
2. Single-Phase Voltage Doubler	Higher voltage for low current devices, such as X-ray equipment, dust precipitators, and projection C.R. tubes	Poor regulation—cost of transformers and condensers is kept down—lower voltage valves can be used as peak inverse volts are halved
3. Single-Phase Full-Wave	1. Small transmitters 2. Large amplifiers and all medium power equipment	Good regulation, easier to smooth
4. Bi-Phase Half-Wave	Most low and medium power applications such as commercial radio sets, etc.	
5. Polyphase	Most heavy power equipment such as large transmitters and industrial heating equipment.	Easy to smooth—very low impedance source

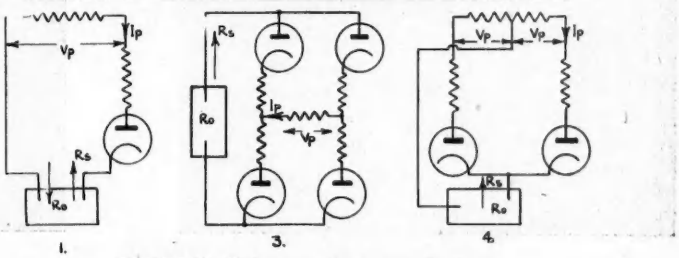
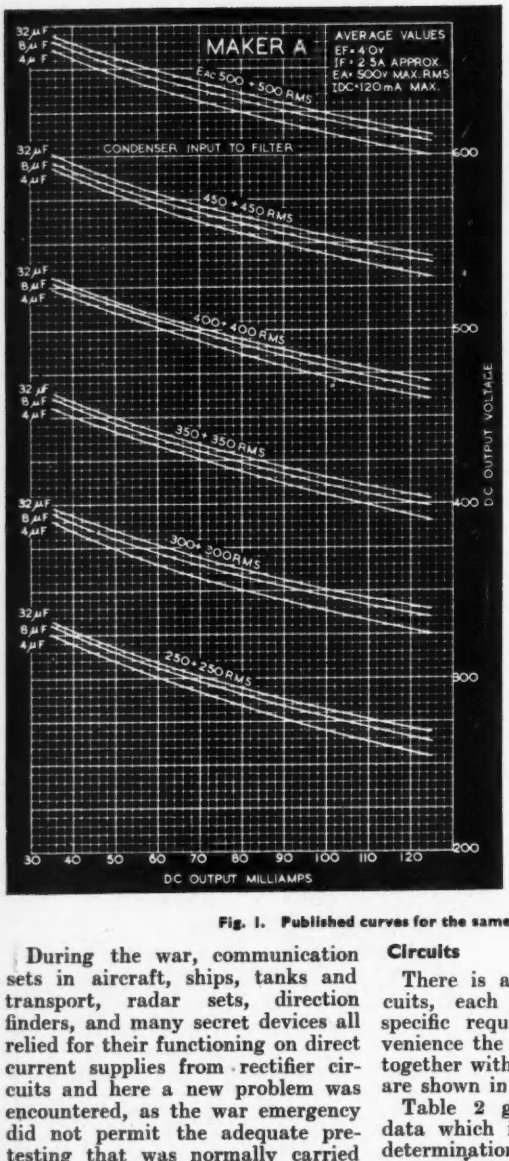


TABLE II—Voltage and current Ratings

Description		1. Single-Phase Half-Wave	2. Voltage Doubler	3. Single-Phase Full-Wave	4. Double-Phase Half-Wave
No. of valves required		1	2	4	2
Trans. secondary volts V_p	Choke	—	—	1.28 Vdc	1.28 Vdc
	Capacitor	1.03 Vdc	0.56 Vdc	1.03 Vdc	1.03 Vdc
Trans. secondary current I_p RMS	Choke	—	—	2.9 Idc	2.05 Idc
	Capacitor	2.1 Idc	3 Idc	3 Idc	2.1 Idc
Peak inverse volts	Choke	—	—	2 Vdc	4 Vdc
	Capacitor	3.3 Vdc	1.75 Vdc	1.6 Vdc	3.2 Vdc
Peak anode current	Choke	—	—	5 Idc	5 Idc
	Capacitor	6.2 Idc	6 Idc	6 Idc	6 Idc
Ripple frequency		1f	2f	2f	2f
Ripple amplitude	Choke	—	—	50%	50%
	Capacitor	15%	10%	10%	10%
Min. full load source resistance rate R_s/R_o	Choke	—	—	0.16	0.16
	Capacitor	0.08	0.04	0.16	0.16
$\omega R_o C$	Capacitor	10	5	5	5



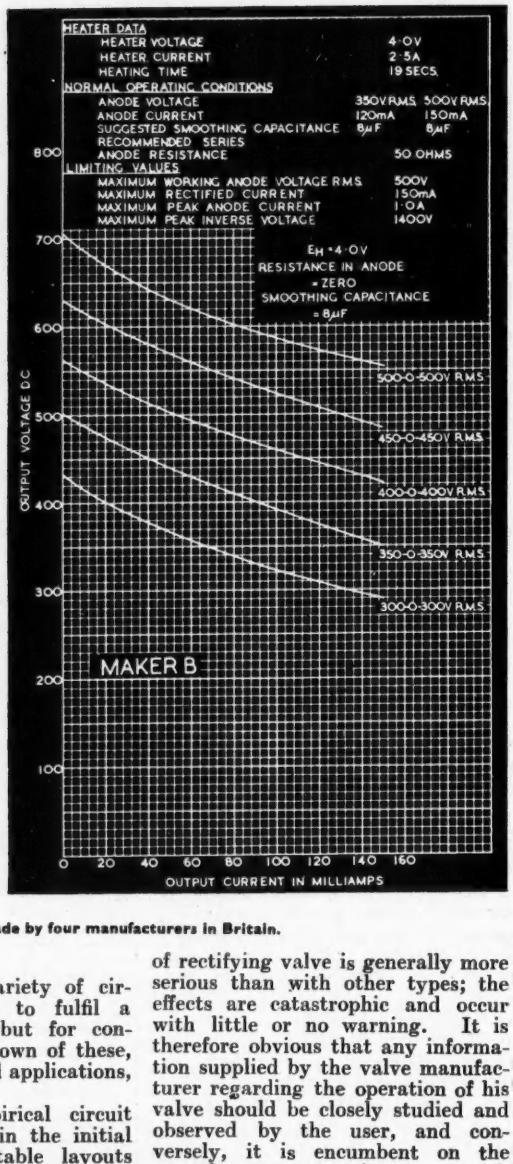


Fig. 1. Published curves for the same valve as made by four manufacturers in Britain.

During the war, communication sets in aircraft, ships, tanks and transport, radar sets, direction finders, and many secret devices all relied for their functioning on direct current supplies from rectifier circuits and here a new problem was encountered, as the war emergency did not permit the adequate pre-testing that was normally carried out on commercial equipment. What was more disconcerting was that the designer was absorbed in the primary purpose of the equipment and in all too many cases the rectifying unit was very much an afterthought to be hurriedly designed and then squeezed into any small remaining space. This led to considerable effort to co-ordinate the design of valves and equipment, and to some of the work described later.

Circuits

There is a great variety of circuits, each designed to fulfil a specific requirement, but for convenience the better known of these, together with the usual applications, are shown in Table 1.

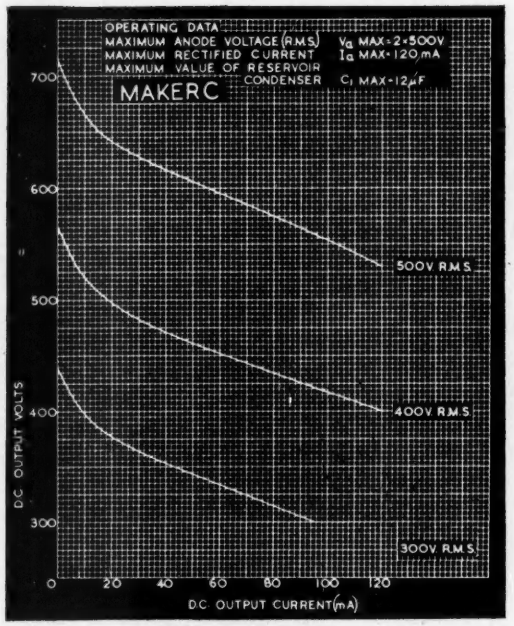
Table 2 gives empirical circuit data which is useful in the initial determination of suitable layouts and which embraces the well-known circuits. It is considered, however, that it is possible with single phase working to cover adequately all needs by two circuits only, the biphase half-wave (B.P.H.W.) and the doubler.

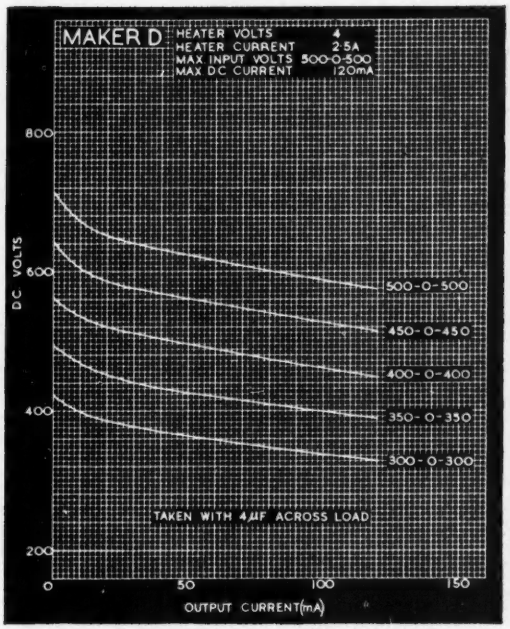
Ratings

The correct use of rectifying valves in the circuits described is a matter of vital importance to both valve manufacturer and circuit designer, because a wrong choice of rectifying valve is generally more serious than with other types; the effects are catastrophic and occur with little or no warning. It is therefore obvious that any information supplied by the valve manufacturer regarding the operation of his valve should be closely studied and observed by the user, and conversely, it is encumbent on the manufacturer to give as much information and guidance as is possible.

This information is issued in the form of "Ratings."

However, a determination of what shall be specified by the valve maker presents great difficulty because the factors of interest to the circuit designer are subject to a number of variable parameters. The variations in these are not easily interpreted by practical mathematical solution and therefore re-





course to empirical generalised curve data is necessary.

Existing Rating Practice

The present unsatisfactory state of affairs is best illustrated by referring to Table 3, which gives the main ratings quoted by five British and one American valve manufacturer. As a rule, maximum R.M.S. applied voltage, maximum direct anode current and maximum D.C. output voltage are nearly always quoted, but there is clearly no evidence of a consistent plan. Furthermore, the fact that there is no common basis of circuit definition and set-up is well demonstrated by examining the published curves for the same valve as made by four British manufacturers (Fig. 1). These differences became evident during the war when it was essential that valves made by any manufacturer should be interchangeable in a multiplicity of Service equipment. It also became apparent that circuit design from first principles was not usual and that some simplified but standardised form of presentation was desirable. For these reasons valve technicians collaborated with Service representatives and produced the "Rating Tables" shown in Table 4. These have been used with some success, but it was the opinion in the authors' Company that further work was needed, and this led to the scheme described later whereby the design of all normal circuit constants becomes just a matter of consulting tables and curves. As will be seen, the data considered necessary is comprehensive in that it not only specifies full load ratings, but also covers fractional ratings, so that designers using valves below their maximum on any particular parameter can stress these valves up to their maxima on other parameters.

TABLE III—SUMMARY OF PUBLISHED RATINGS, 1939

Valve Manufacturer	Valve Type	No. Examined	Max. RMS Voltage	Max. D.C. Current	Max. Peak Inverse Voltage	D.C. Output Voltage	Valve Voltage Drop	Peak Anode Current	Condenser
1	Vacuum	20	20	20	4	18	1	3	19
2	„	11	11	11	4	11	1	3	11
3	„	22	22	22	—	—	—	—	—
4	„	13	13	13	—	10	—	—	—
5	„	12	12	12	4	8	3	4	9
6	„	27	27	27	25	22	27	26	—

The New Rating Scheme

As has been shown, existing methods of operating rectifying valves place little emphasis on circuit conditions, with the result that the actual valve loading may vary considerably from circuit to circuit. The conventional "regulation" curves at present published neglect the effects of circuit components and assume a perfection of transformers, etc., completely uneconomic for commercial practice. Similarly, very little attention has been paid to vital matters such as current and voltage switching surges.

It is considered that this situation arises chiefly because of the difficulty of measuring quantities of primary importance to operation such as the anode dissipation and the peak anode current. These measurements are not easily made in the field and therefore attempts have been made to limit them indirectly by specifying other quantities which are more easily measured.

The scheme described permits that, with a knowledge of the required output in voltage and current only, the user can calculate the input required and also determine the main design data of the associated components in the circuit.

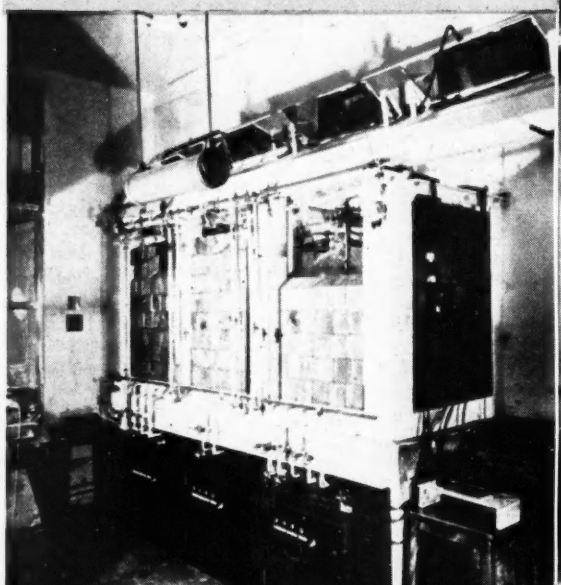
(*Continued on page* 290)

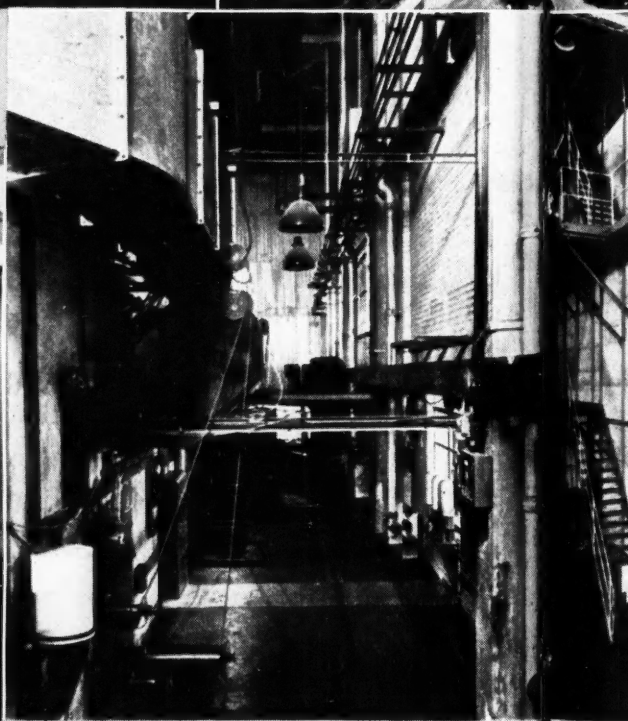
Atomic En[illegible]y R[illegible]

Views Taken at th[illegible]arwell

Above : The control room for Gleep

Below : Radiochemical laboratory. Experiments are carried out behind the protective lead walls which can be built up to any desired size by interlocking bricks. Operations are controlled remotely and observed by means of mirrors over the apparatus





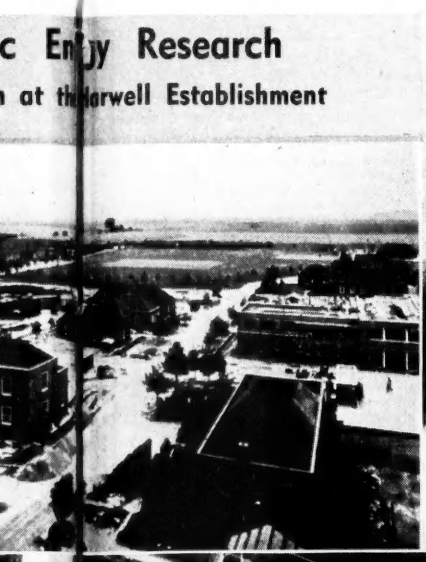
Top centre : General view of th[illegible]mic Energy

Gleep. The " control " face is on the left. In the bottom corn[illegible]General vie[illegible] can be seen the chambers containing boron trifluoride which [illegible]nto the Pil[illegible] used to measure the intensity of neutrons in the pile, and hence [illegible]he right. [illegible] control the power level at which the pile is operated [illegible] thermal [illegible] or[illegible]

All photographs are [illegible]n copyright [illegible]

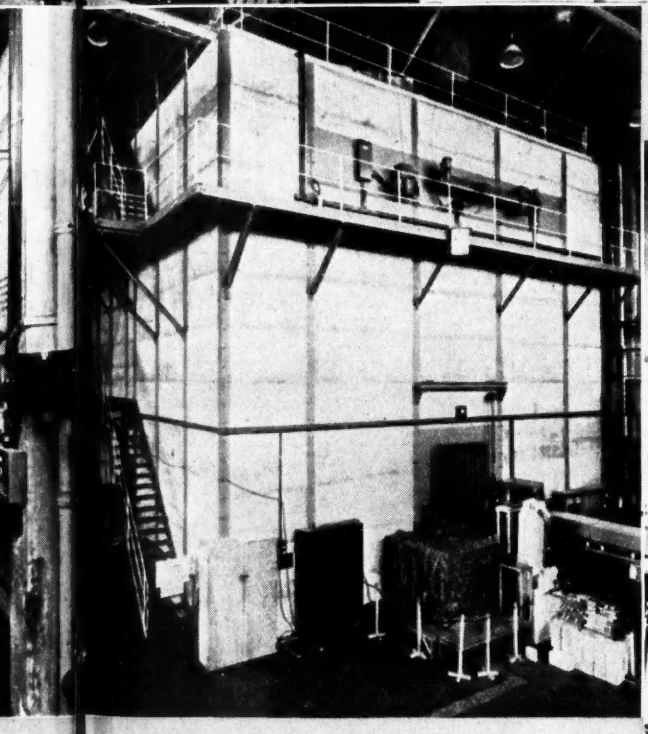
c En gy Research

n at th arwell Establishment



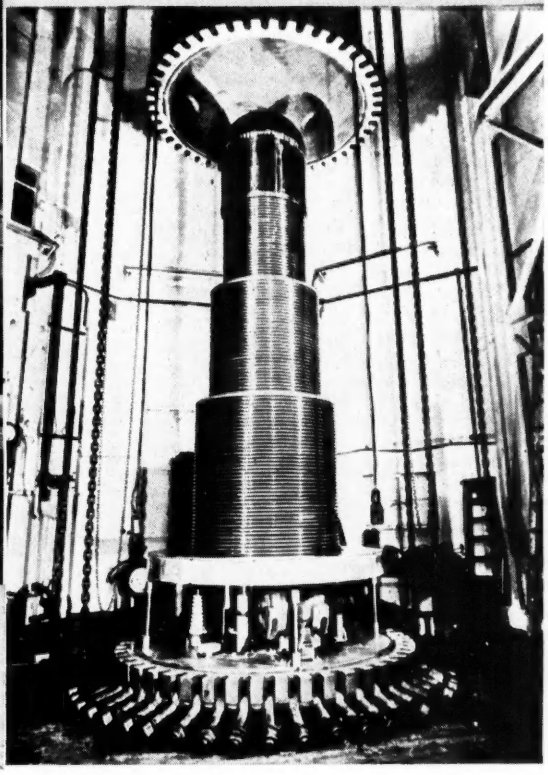
Above : Production of radioactive isotopes. A sample is being taken out after irradiation in Gleep. The operator is protected from radiation from the material by the lead tunnel (shown with handles) through which the samples are taken with tongs. They are placed in the lead pots (centre) for transport

Below : Van de Graaf high voltage generator. When in use the machine is enclosed by the cover (top centre) which is filled with gas under pressure



iew of th mic Energy Research Establishment

ttom corn General view of Gleep. The holes, through which samples are put e which p nto the Pile for the production of radio-isotopes, are in the face on nd hence the right. In the same face a square screen of lead blocks covers the rated " thermal column," a column of graphite used to produce slow, or " thermal," neutrons for experimental work



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(*Continued from page* 287)

Parameters

In a given type of rectifier the waveforms are functions of two parameters, provided that the circuit inductance is small compared with its resistance.

To maintain constant ratios of peak/mean anode current, R.M.S./mean anode current, etc., it is necessary to quote constant values for the two controlling parameters, after which the anode dissipation and the peak anode current values are entirely determined by the value of the mean anode current.

The whole investigation has been carried out on a practical basis. An experimental survey has been made covering as wide a field as possible and this included measurements of transformer characteristics, valve characteristics and filter circuits for a representative group of valves operating under published valve catalogue conditions, under normal working conditions, and finally under conditions evolved as a result of the work done. Careful checks were also made of the ratio of actual to no-load peak inverse voltage for the same group of conditions.

The facts obtained enabled a table to be prepared giving values for the waveform ratios of various circuit arrangements when the parameters were adjusted to the recommended values. All valve loadings were expressed in terms of the rated maximum peak inverse voltage or rated maximum mean anode current. From the table it was possible to evaluate the ratings for a given valve type for all common single phase circuits so that it is fully but safely loaded throughout.

It was considered that limiting ratings should be specified for peak inverse voltage, mean anode current, peak anode current, peak surge current, surge repetition and minimum inductance. Such ratings applied to maximum valve loading conditions, but the work has been extended to cater for fractional loadings. If certain reasonable assumptions are made the variation of the parameters can be predicted and fractional load performance curves can be logically deduced from the maximum loading conditions.

The ratings have all been based on a peak/mean anode current ratio of 6/1. Most published regulation curves have been taken under onerous conditions with ratios sometimes as high as 8/1 and for this reason the new ratings in some cases entail a slight reduction in the maximum rated output to be obtained from a given input, but it is known that the appreciably higher values are only achieved by using components of uneconomic size.

Low power rectifying equipments are frequently switched on at full primary voltage, producing surges of voltage and current in the rectifying valve with possibility of failure due to insulation breakdown or "flash arc." Such surges have been carefully investigated and it has been found that while capacitance input circuits do not produce serious surges, bad conditions are obtained in choke input circuits with the filament hot at the time of switching. All such surges are covered by a figure of twice the no-load peak inverse voltage. Current surges appear to have a duration of the order of 100 mS, while voltage surges have a frequency of 10 Kc/s.

TABLE IV—STANDARDISED RATING SCHEME DEVISED DURING THE WAR

Rating	Remarks
1. Type of valve	Oxide coated, etc.
2. Type of cathode	Directly or indirectly heated
3. Filament or heater voltage ...	—
4. Filament or heater current ...	—
5. Max. applied R.M.S. A.C. input voltage	As applied to single-phase half-wave
6. Max. working peak inverse voltage	This is the maximum under steady running conditions
7. Max. no-load peak inverse voltage	This is an absolute maximum and applies to any possible conditions which may arise during switching and starting peaks, transients and waveform distortions
8. Max. D.C. output current ...	—
9. Max. peak anode current ...	—
10. Preheating time where necessary	—
For Condenser Input Filter Only	
Max. reservoir condenser	—
Min. limiting resistance per anode for max. rated conditions	Calculated as the difference between the safe source resistance and the valve impedance If the resistance of the transformer secondary together with that of the primary and its controls all referred to the secondary winding, does not equal the quoted figure, then a resistance equal to the difference must be inserted in the circuit.
For Choke Input Filter Only	
Min. value of inductance at max. current	This is to limit the peak current to a safe value

TABLE V—RATINGS FOR MU14 VALVE

(*a*)	Heater voltage (R.M.S.)	4.0
(*b*)	Heater current	Approx. 2.5 amps.
(*c*)	Max. R.M.S. input phase voltage on no-load	See table below.
(*d*)	Max. output current	See table below.
(*e*)	Max. peak inverse voltage	1430 V.
(*f*)	Max. peak anode current	370 mA.
(*g*)	Peak surge reverse voltage	2960 V.
(*h*)	Peak surge anode current	1.2 amps.

MAXIMUM LOADS IN CAPACITY INPUT CIRCUITS.

Circuit	B.P.H.W.	Doubler	S.P.H.W.	S.P.F.W.
(1) No. of valves used	1	2	1	4
(2) Recommended input capacity (μF) when supply frequency is 50 c/s.	4.0	2.0	8.0	4.0
(3) Minimum source resistance—ohms. ...	645	310	310	645
(4) Total effective valve resistance—ohms. ...	200	100	100	200
(5) Max. no-load input phase voltage (R.M.S.)	500	500	500	1000
(6) Max. output voltage (D.C.)	485	900	470	970
(7) Max. output current (mA)	120	120	120	240
(8) Max. mean anode current (mA)... ...	60	60	60	60

and a damping of 1 mS. The maximum current surges due either to short circuits or switching do not exceed three times the peak current.

A suitable allowance for waveform distortion effect on peak inverse voltage was found to be an increase from the usual $2\sqrt{2}$ the phase voltage to 3.1.

Presentation of Data

The curves provided will relate output voltage, R.M.S. phase current and total effective anode resistance to output current.

Table 5 and Figs. 2 and 3 are representative and show the data given for the M.-O. MU14. rectifier.

In the Ratings table (Table 5), the circuit used is immaterial excepting for items (c) and (d).

The full load performance table gives the output performance of the valve when operated in any of the four capacitance input circuits stated. It should, however, be noted that in the case of the input capacitor in the Doubler circuit, this is the series capacitance of the two capacitors which are across the output from the valves.

The use of the performance curves is best illustrated by taking an example:

Suppose an output of 900 volts 100 mA is required with a ripple not exceeding 1 per cent. Examination of possible types and circuits shows that a convenient arrangement is a voltage doubler circuit using two MU14 valves. Then from Fig. 2 V_o = 900 V, I_o = 100 mA gives an R.M.S. phase voltage of 491 V. From the horizontal scales I_o = 100 mA corresponds to i_p = 306 mA, which is the transformer secondary current.

The power transformer therefore requires a secondary wound for an open circuit voltage of 491 V to carry 0.306 amps. R.M.S. current.

Also from Fig. 2,

$$C = \frac{16{,}000\ I_o}{V_o}\ \mu F = 1.8\ \mu F$$

Since in the doubler circuit this capacity consists of two in series, each condenser requires to be 3.6 μF, say, 4 μF.

Also from Fig. 2 the minimum source resistance is 0.62 V_p = 0.62 × 491 = 305 ohms, and from the scale of total effective valve resistance it is seen that at I_o = 100 mA the valves contribute 104 ohms. Hence the resistance of the power transformer referred to its secondary plus the valve resistance must be subtracted from 305 ohms to find the additional resistance required.

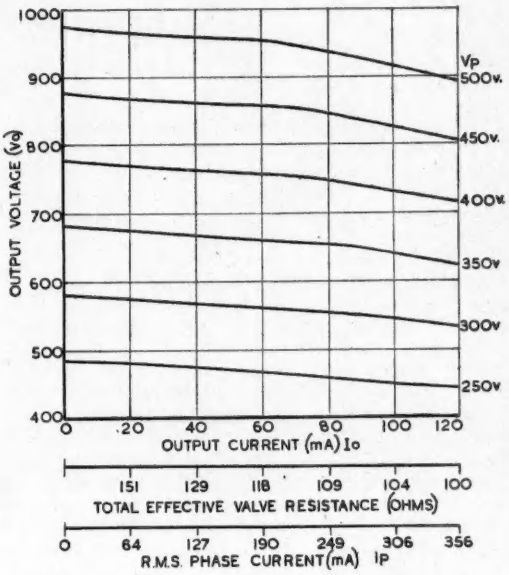


Fig. 2. Performance curves for MU. 14 valve in voltage doubler circuit with capacitance input.

Minimum source resistance 0.62 V_p ohms.

Recommended value of C

$$= \frac{16{,}000\ I_o}{V_o}\ \mu F.$$

Ripple (r.m.s.) 10% V_o at 100 c/s.

$$\omega R_o C = 5.$$

Fig. 3. (below) MU.14 operational curve for choke input circuits.

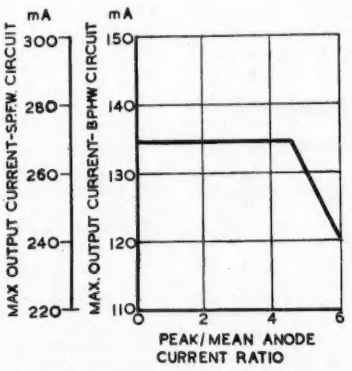


Fig. 2 is set for a 10 per cent. ripple at a ripple frequency of 100 c/s. and therefore to achieve a 1 per cent. value, additional smoothing with an attenuation of 10:1 must be provided.

To cater for choke operation a further curve as shown in Fig. 3 is supplied. This shows the permissible increase in output current for a given reduction in peak/mean anode current ratio. The curve relates to the B.P.H.W. and S.P.F.W. circuits as the only ones likely to be used with choke input.

Proposed Scope of the System

At present, detailed consideration has only been given to condenser input filter circuits as there is little point in using choke smoothing on either single phase half-wave or voltage doubling circuits. The advantage of greater output current achieved by the use of a choke is off-set by a reduction in output voltage on account of the reactance and resistance of the choke.

It is thought that the scheme will only apply to the lower powered oxide-coated rectifying valves. In the higher power field lower values of peak/mean ratio are used and in any case the use of lower emission efficiency tungsten filament valves and three phase circuits makes the scheme not applicable. Therefore for larger valves it is still considered best to provide only the primary parameters of peak inverse voltage, peak and mean space currents, maximum peak anode current and a voltage/current characteristic of the valve.

This system is described in detail in a paper "The Rating of Small and Medium Power Thermionic Rectifiers" by H. T. Ramsay, B.Sc., M.I.E.E., published in *J.I.E.E.*, Part III, July, 1947.

Acknowledgement

The authors would like to thank the Marconi Osram Valve Company for permission to publish these articles and for facilities given in connexion with the photographs shown in Part 2.

Simplified Connexions

By J. R. FAWCETT B.Sc., A.M.I.Mech.E.

THE conventional method of making connexions in radio and similar apparatus by means of wires soldered to tags on the various components is costly and often rather complicated. Where H.F. currents of comparatively low power have to be handled, conductors made of thin strip directly fastened to an insulating panel to which many of the components are also fitted make an attractive alternative for some purposes. The method used is to lay down by some means, on the insulated panel, a modification of the theoretical diagram represented by metallic conductors to which the other connexions are made at suitable points.

For simple circuits without cross-overs, and where the currents are very small, it has been found practicable to actually print the conductors on to the panel using a silver "ink." This can be done on an ordinary printing machine, preferably one of the offset variety which uses a rubber-covered roller to transfer the ink from the printing block to the work. The rubber gives sufficient resiliency for a perfect impression to be made, even if the panel is not quite flat. The printing block is an ordinary zinc which can be made by any process engraver by photographing a true-to-scale drawing. Care should be taken that the block is made the correct way for the printing process employed. If the offset process is used then this must be made clear as most blocks are made for letterpress work and these would give a reversed impression if used on an offset machine. After printing, holes are drilled in the panel for taking tagged eyelets to which the connexions can be soldered.

A similar method, but one which gives rather more substantial conductors, uses sprayed metal. Many metals can be sprayed in the form of a fine mist by using a special "gun" which melts a wire and blows the molten particles in the same manner as a paint spray gun. Although the particles are molten

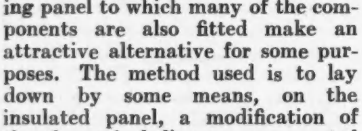
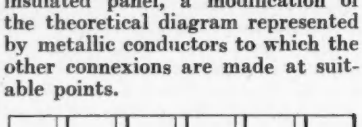
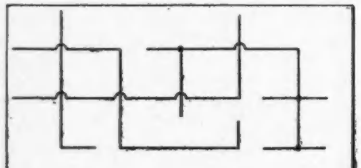


Fig. 1. Panel with conductors, before dividing up

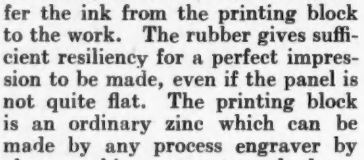


THEORETICAL DIAGRAM
(Without Components)

Fig. 2. Above: Theoretical diagram without components. Below: Panel laid out with conductors according to the diagram



FINISHED PANEL



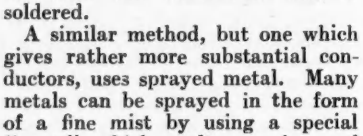


Fig. 4. Sketch showing formation of cutting tool

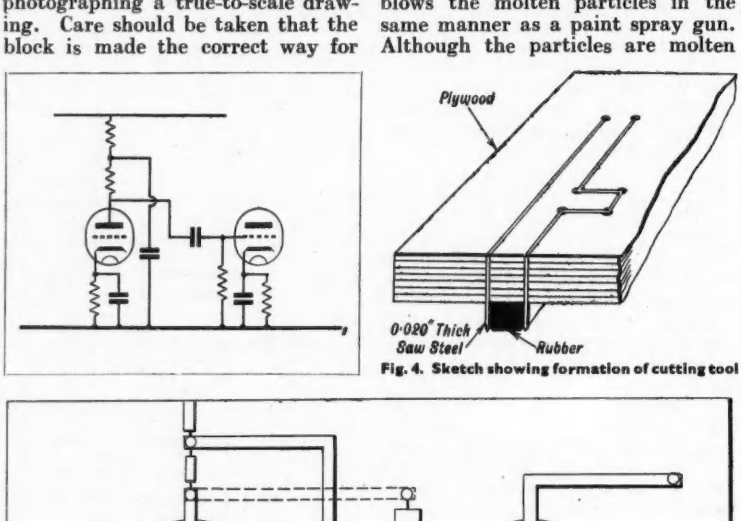


Fig. 3. Mass-produced panel wired with conductors in conformity with the theoretical diagram above.

when they touch the surface being sprayed, the amount of heat they carry is small and paper base insulators can be used without any fear that they will be damaged by heat. If the panel is covered with a stencil pierced with the pattern of the conductors and then carefully sprayed with a thin film of copper the complete conductor layout can be quickly formed. To improve the adhesion of the sprayed metal, the panel may be sandblasted first.

When such unconventional methods are not favoured, a similar but more substantial result can be obtained by making the conductors of copper strip. A most versatile method which can be adapted to a variety of circuits makes use of two rows of parallel copper strips, one on either side of the panel, and the strips on one side being at right angles to those on the other (Fig. 1). To wire up, the conductors are linked by drilling through the nodal points and connecting the conductors on either side of the panel with eyelets or cutting out lengths of strip (Fig. 2). Where mass production methods can be employed the scheme is modified by fitting shaped strips to the panel, the strips being arranged on either side of the panel to give the desired result (Fig. 3). For cutting out and fixing the conductors to the panel a tool is used which is similar to that used by printers for cutting paper into irregular shapes. The construction of one of these tools is shown in Fig. 4, and they may be obtained quite cheaply made to cut out any desired design. Copper foil about .005 in. thick is used and a sheet of this is placed on the panel with a sheet of thermo-setting adhesive between them. The panel with the cutting tool on top is inserted between the platens of a hydraulic moulding press which are heated to a suitable temperature for the adhesive. Pressure is applied sufficient to cut through the foil and compress the rubber on to the parts which are to adhere. After removing from the press the surplus foil is stripped off and holes are drilled for fixing such components as are attached direct to the panel and for eyelets for the other connexions.

The B.T.-H. Summer School for Professors of Electrical Engineering attracted many well-known figures in the university world. The photograph shows Dr. K. J. R. Wilkinson (B.T.-H. staff) explaining a 100 KV potential divider and model of an impulse generator to Professors W. J. John (Queen Mary College), Willis Jackson (City and Guilds), B. Hague (Glasgow), R. O. Kapp (University College), and M. G. Say (Edinburgh). The course lasted from July 12th to July 16th and included a series of over 20 lectures on advanced subjects by the B.T.-H. staff

SEPTEMBER LECTURES

British Sound Recording Association

Date: September 23. Time: 7 p.m.
Held at: The Royal Society of Arts, John Adam Street, London, W.C.2.
Presidential Address
By: W. S. Barrell.
Hon. Secretary: R. W. Lowden, "Wayford," Napoleon Avenue, Farnborough, Hants.

The Television Society

The Annual Fleming Memorial Lecture will be given at the Royal Institution, Albemarle Street, London, W.1, on Wednesday, September 29, at 6.30 p.m.

Tickets of admission for non-members can be obtained from the Hon. Lecture Secretary, *Mr. T. M. C. Lance, 35 Albemarle Road, Beckenham, Kent.*

South-East London Technical College

Electrical Engineering Department

The following information of proposed special courses to be held at the College has been issued.

Industrial Electronics — about 25 lectures.
High Vacuum Technique — about 6 lectures.
Applications of the Cathode Ray Tube to Industrial Problems — about 6 lectures.
Television — two courses, one of about 12 lectures and one of about 30 lectures and practical work.
Electronic Equipment and Instrumentation — about 6 lectures.

Further details may be obtained from the Principal, South-East London Technical College, Lewisham Way, London, S.E.4.

British Association for the Advancement of Science

The 110th Annual Meeting will be held at Brighton on September 8 to September 15 inclusive.

Details may be obtained from British Association Office, Burlington House, London, W.1.

The Polytechnic, Regent Street, London, W.1.

Department of Mathematics and Physics

A post-graduate course of lectures on "Electronics" will be held on Thursday evenings from 7 to 8.30 p.m. commencing September 30, 1948. The course is divided into four parts:—

September 30 to November 4 — "Emission of Electrons from Solids."
November 11 to December 16 — "Amplifiers and Oscillators."
January 18 to February 17 — "Electron-Optics."
February 24 to March 31 — "The Electron Microscope."

Enrolment may be made for the whole course or for any one part.

Enrolment forms may be obtained from the Head of Department of Mathematics and Physics.

Fig. 2. The monitor and its power supply unit

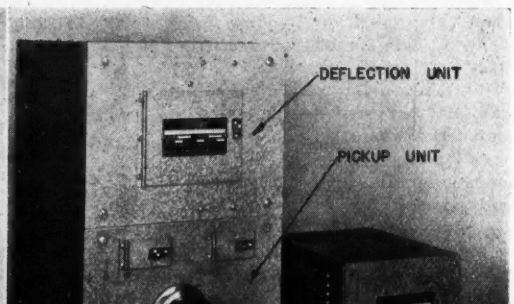


Fig. 1. The camera and its power supply unit

Industrial Television

By JOHN H. JUPE, A.M.I.E.E.

TELEVISION has so far been considered chiefly as a means of entertainment and, with the exception of a few medical operations involving its use for large-audience presentation, has not yet entered the serious field. Considered as a telecommunication system distinct from normal radio it has two important features of its own that entitle it to a special place in the industrial arena.

(a) It can go where men cannot go or where it is inadvisable for them to go.

(b) It is probably the most highly developed system for conveying a large amount of information to a distant point in a short space of time.

Its use as an industrial aid will depend on the economics of the installation and a study of the various factors reveals that the following requirements are fundamental.

1. It must either convey correct indications or none at all.

2. The angle of vision must be a wide one.

3. The equipment must operate 24 hours a day, 7 days a week if necessary.

4. The initial outlay and maintenance costs must be reasonable in comparison with the industrial value of the system.

5. The use of mechanical or moving parts at the point of transmission should be avoided.

With these points in mind a careful study of the industrial field indicates that the economical possible applications for such a system are:

1. A positive flame detector.

2. Detection of slag flow and metal flow from furnaces.

3. Remote pressure and level indication.

4. Observance of water turbulence and foreign material in industrial hydraulic systems, *e.g.*, hydro-electric power plants.

5. Underwater work of many kinds.

6. Monitoring and interlocking on railways.

7. The monitoring of dangerous or inaccessible points in chemical works.

8. Observing radio-active material, atomic power plants.

9. Seeing down wells, especially oil wells.

10. To observe the emission of smoke from stacks.

11. To produce the indications of meters situated at remote, inaccessible or dangerous points.

12. To display charts, card records or other documents to personnel at remote points.

The power plant field, especially the newer and larger plants, offers a splendid application of television because the boilers in such installtions are, in many cases, six or more stories high, and it is necessary for the control engineers to watch the water level very closely because in most instances, owing to the enormous rate of evaporation, there is little water storage capacity and complete emptying is only a matter of seconds.

This demands very reliable water level indication because the damage that could occur from loss of water is tremendous, and the Hell Gate power station of the Consolidated Edison Company, New York City is probably one of the world's first examples of extremely valuable plant being entrusted to industrial television for its safety.

The equipment was designed as a result of the combined researches of the Farnsworth Television and Radio Corporation and the Diamond Power

Speciality Corporation and is offered as "television in industry" under the name of "Utiliscope."

It consists essentially of four units: camera and deflection unit, two small power units, and a monitor (viewing) unit.

Fig. 1 shows the camera and its power supply unit while Fig. 2 shows the monitor and its power supply unit.

The Farnsworth Corporation, who did the circuitry and electronic development, selected their image dissector tube as the photo-electric pickup device because of its colour response and long life. The sensitive surface is of the caesium oxide-silver type and the dissector has an output of 20 to 40 mA. per lumen of tungsten radiation at 2780° K. This signal output is passed through an electron multiplier having a multiplying ratio of 1,000,000. The deflector circuits of the tube are arranged for a 250-line image, 60 frames per second and are non-interlaced. The vertical oscillator is locked to the A.C. supply mains and the horizontal sweep circuit is locked to this oscillator. A sweep-frequency of 15 Kc/s is used, obtained from a single 6L6 valve.

The cathode ray tube in the receiver is a 10CP1 which has a green screen, selected because green is a restful colour for the eyes. Deflection circuits and focusing circuits in the receiver are similar to those in the camera, except that the vertical and horizontal signals from the camera control the oscillators in the receiver. One to five receivers may be connected to a single camera, thus permitting the picture to be received simultaneously at several points.

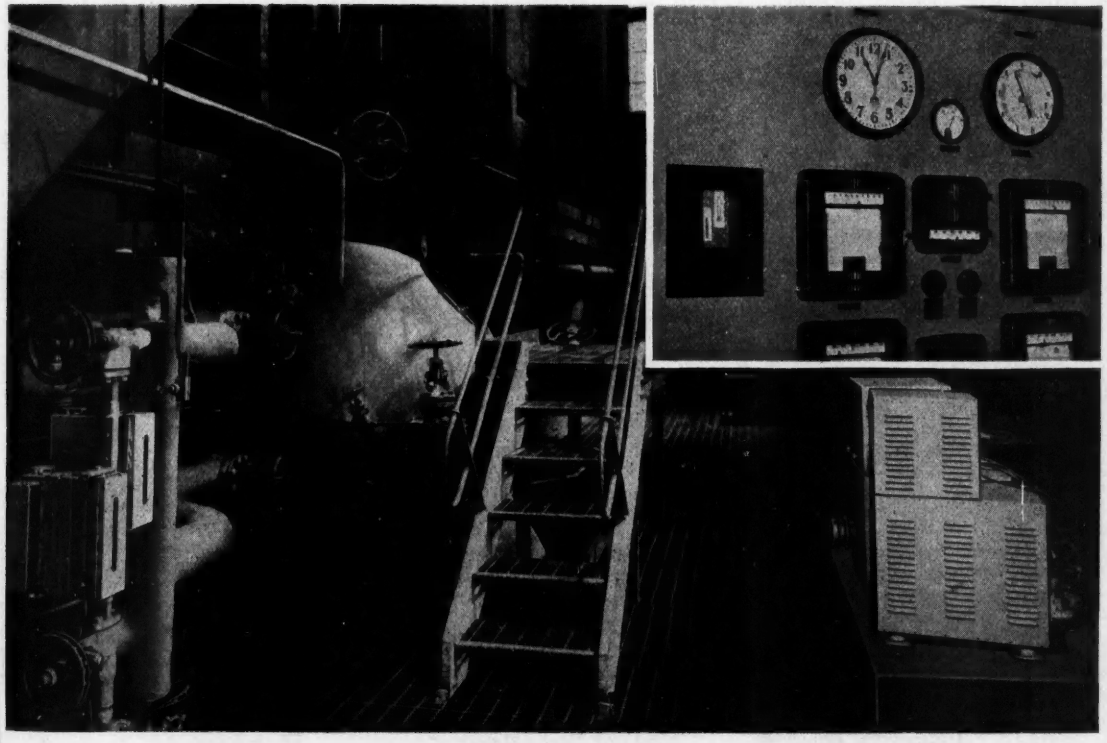
The camera can view a wide field and the cathode-ray monitor also has wide viewing angle, 160 degrees. By using a two-colour water gauge, as at the station quoted, the equipment will differentiate sharply between the two colours. This can be seen quite clearly in Fig. 3, which shows the monitor mounted on the instrument panel of the boiler. In this case it was situated 325 ft. away from the boiler, in another building, but the maximum distance to which information can be transmitted is approximately 1,000 ft. Fig. 4 shows the installation mounted in a boiler room.

The image dissector tube requires a minimum illumination of 800 foot-candles, but in most cases this can be obtained by using one 300-watt spotlight.

Camera and viewing units are both protected from vibration and are designed for operation at a permanent room temperature of 150° F. The total weight of the units is 125 lb. when in operation they consume a total of 250 watts.

The Hell Gate installation has presented no servicing or maintenance problems and already there have been repeated suggestions to extend the Utiliscope service to allied matters of smoke indication, steam pressure and furnace combustion viewing.

Fig. 3. Utiliscope camera unit focused upon boiler water gauge at Hell Gate Station
Fig. 4. (*inset*) Utiliscope monitor (or viewer) mounted in instrument panel in control room. At left is enlarged view of image on monitor screen.



THE MANCHESTER ELECTRONICS EXHIBITION

THE third Exhibition held under the auspices of the Institute of Electronics at the College of Technology, Manchester, on July 20-22 was attended by over 2,000 technical visitors and students. As before, great credit is due to the organising committee of the Institute and to its secretary, Mr. L. F. Berry (Ferranti, Ltd.), for the success of the Exhibition.

The following items were noted among the stands, some having been exhibited for the first time:

Chloride Electrical Storage Co.

Various special electronic applications of Exide dry batteries and chloride accumulators, including a prototype miniature H.T. and L.T. battery for use with Radio Sonde equipment. Also shown was a ship's lifeboat transmitter working in conjunction with an Exide self-priming battery, and a battery operated oscilloscope. Inquiries to:

Whitfield House,
Whitfield Street, London, W.1.

Ferranti Ltd.

A new precision test equipment for C.R. tubes designed to provide a precise system of line, frame, and modulation signals with stabilised potentials for operating magnetic tubes.

Special attention has been paid to the features which facilitate the measurement of spot characteristics. Inquiries to:

Ferranti Ltd.,
Hollinwood Lancs.

Mullard Electronic Products Ltd.

A range of miniature valves in all-glass construction for telecommunications and industry. This includes the following types:

UCH.42—Triode hexode.
UAF.42—Single diode pentode.
ECH.42—Triode hexode.
UL.41—Output pentode.
EF.42—High slope H.F. pentode.
EL.41—Output pentode.

Two new miniature photo-cells are the 90AV, a vacuum cell with antimony-caesium cathode, and the 90CG, a gas-filled cell with caesium on oxidised silver cathode. The latter has a high sensitivity to infra-red and incandescent illumination. Inquiries to:

Mullard Electronic Products, Ltd.,
Shaftesbury Avenue, W.C.2.

Metropolitan-Vickers Ltd.

Several items of laboratory equipment are available, among them being:

A stabilised power unit providing D.C. output up to 150 mA at a voltage variable between zero and 400. Stability ± 0.01 per cent. with mains variations of ± 10 per cent.

Multi-range valve voltmeter suitable for A.C. and D.C. ranges from 1 mA to 1 A and voltages from 1 V to 1 KV.

Miniature oscilloscope Type 244, with $2\frac{1}{2}$-in. screen, complete with linear push-pull time base and amplifier. Inquiries to:

Metropolitan-Vickers, Ltd.,
Trafford Park, Manchester.

The General Electric Co. Ltd.

In addition to the Miniscope, now fitted with a double-beam unit (*see* ELECTRONIC ENGINEERING, February, 1945), the following laboratory equipment was shown:

A new design of "Q" meter for measurement at frequencies up to 150 Mc/s.

Layer thickness meter, for measuring the thickness of non-magnetic coatings on magnetic material, *e.g.*, paints, electro-deposited metals, etc.

A moisture meter for estimation of moisture in timber, but which can be extended to other uses such as tobacco, grain, or paper. An accuracy of ± 2 per cent. is obtainable with timber without special corrections, and the whole instrument is compact and portable.

The General Electric Co., Ltd.,
Magnet House, Kingsway, W.C.2.

Siemens Electric Lamps & Supplies Ltd.

High brightness mercury vapour lamps for projection and other optical uses. Compact source types range from 125 W to 10 KW, and 500 and 1,000 W types are available water-cooled.

The "Sieflash" S.F. tubes are xenon-filled flash tubes suitable for photography in monochrome or colour, and special types of flash tube are available for high speed photography. Inquiries to:

Siemens Lamps, Ltd.,
Dock Road, Preston, Lancs.

Muirhead & Co. Ltd.

The battery-operated *p*H meter type D-417-A is an inexpensive instrument suitable for bench work, and is supplied complete with electrode assembly and accessories. The meter gives a total effective scale length of 7½ in. for a full range of 0-15 *p*H units. Price £42.

"Magslips" for remote control and position indication were shown. The indication is effected by the synchronous movement of two rotors, one at the actuating end and the other at the receiving end of the system. The stators consist of a laminated ring with three sets of windings arranged at 120°. The rotors are energised from an A.C. supply, and the stator windings are connected together "phase for phase." Voltages will be induced in the stator winding of the transmitter of a magnitude depending on the position of the rotor, and the current flowing between the two stators will interact with the rotor current to produce a torque which will turn the receiver rotor to the same relative position as the transmitting rotor. The accuracy of movement is within 1° for a simple receiving mechanism. The full theory and application of these interesting devices is given in booklet B-580-A. Inquiries to:

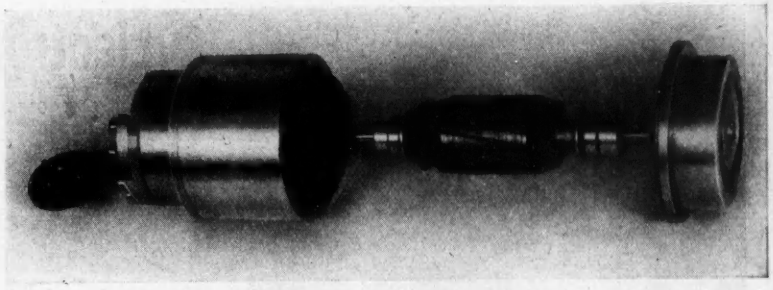
Muirhead & Co.,
Elmers End, Beckenham, Kent.

W. Edwards & Co. Ltd.

A wide range of vacuum measuring instruments includes the Model 7 Pirani Gauge, a new 2-range vacuum gauge with an extended range to 0.0001 mm. Hg. Type 1 of this model has a range of 0.5 mm. to 0.005 mm. A hydrogen leak-testing attachment can be used with the above gauge.

Several types of rotary and diffusion pumps were also shown. Inquiries to:

Edwards & Co., (London) Ltd.,
Kangley Bridge Road, S.E.26.



Exploded view of Muirhead "Magslip" showing rotor

Cossor Radar Ltd.

In addition to the new oscillographs Types 1035 and 1049, this exhibit demonstrated Marine Radar and a miniature Gee Mk. III.

The oscillograph Type 1035 is a double-beam instrument with time base ranges from 150 mS, to 15 μS and a tube diameter of 90 mm. The Y amplifier handles frequencies between 20 c/s. and 7 Mc/s. and has a maximum gain of 3,000. The Model 1049 will handle frequencies between 0 and 70 Kc/s. Inquiries to:

Cossor Radar, Ltd.,
Highbury Grove, N.5.

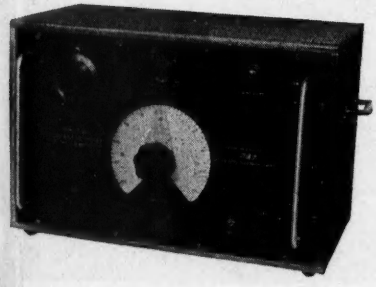
Marconi Instruments

The direct reading *p*H meter, Type TF889 is a self-contained battery-operated instrument for *p*H determination in the range 1-11 *pH* in conjunction with the Marconi glass/calomel electrode system supplied;

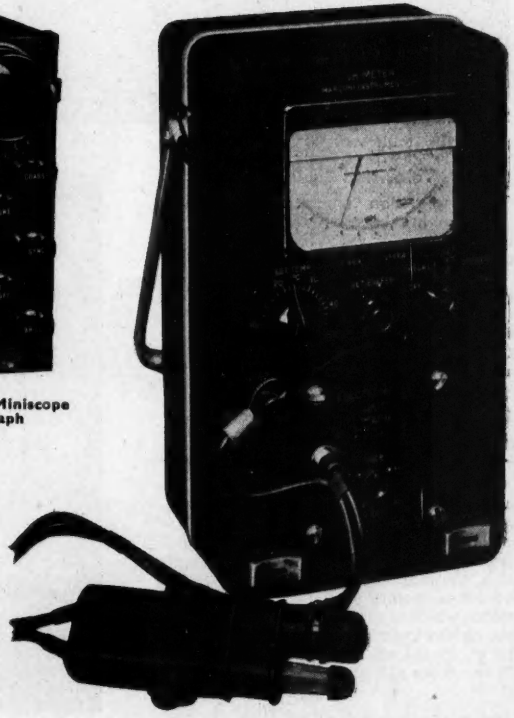
A special feature of the circuit, which is stabilised against battery voltage variations, is the provision of a new self-checking system enabling compensation to be applied for any change in valve slope. Inquiries to:

Marconi Instruments,
St. Albans, Herts.

Above: The G.E.C. Miniscope C.R. Oscillograph



Left: Impedance Comparison Bridge (G.E.C.)



Right: Direct reading *p*H meter of Marconi Instruments

Electronic Equipment

A monthly record of British electronic apparatus, components, and accessories, compiled from information supplied by the manufacturers. Enquiries should be sent to the manufacturers at the addresses given, and it would be appreciated if this journal were mentioned as the source of information.

R.F. Heating Equipment

WITH the introduction of the F.5. model, the range of Philips radio frequency heating equipments has been extended to cover the application of this form of heating to small jobs. There is a wide sphere of useful application for smaller powers, mainly in soft and hard soldering work, "spot" heating and local hardening of small components. The F.5 has a continuously rated output of 2.5 kW. at the terminals.

A six-position matching control switch adjusts the generator to the work, making it possible to obtain full power in a wide range of jobs without laborious work coil design. An on-load continuously variable power control is also provided. Two meters on the front panel indicate valve input current, and generator output current. The other controls on the front panel are a HIGH-LOW power switch, and the generator ON-OFF switch.

The R.F. power is controlled by a foot switch, attached to a length of cable. Dimensions : 60 in. high by 33 in. wide by 28½ in. deep. Power consumption 5 KVA at 0.85 P.F.

Philips Electrical Ltd.
Century House, Shaftesbury Avenue, London, W.C.2.

Activated Rosin-Cored Solder

SUPERSPEED special cored solder contains a non-corrosive chemically activated rosin-based flux which accelerates the soldering process by giving a more vigorous fluxing action, as the viscosity is reduced. The activating agent is destroyed during soldering and there is no corrosive residue. Supplied in 1 lb. and 7 lb. reels. Prices on application.

H. J. Enthoven and Sons,
15-18 Lime Street, London, E.C.3.

Television Equipment

THE television monitoring equipment shown has been specially designed for use in conjunction with the new transmitters under construction for the B.B.C.

The rack on the right is a waveform generator and monitor and on the left is a 15-in. picture monitor tube. The outgoing signal can be viewed at any point in the transmitting chain from camera input to aerial feeder.

Marconi's Wireless Telegraph Co.
Marconi House, Chelmsford'

Audio Frequency Generator

THE type F.1 audio-frequency generator covers a range from 100 c/s. to 10 kc/s. with an accuracy of 2%-25 c/s.

The power output is 1 watt level to within 6 db. over the full range and output impedances of 600, 5, and 10 ohms are available, the latter being the attenuator. The output is monitored by a two-range voltmeter which is automatically switched with the output impedance switch. Dimensions: 13 in. by 10½ in. by 7¾ in. deep. Weight 16 lb. Price £23 10s. subject.

Advance Components Ltd.
Back Rd., Shernall St., E.17.

Battery pH Meter

A direct-reading pH meter which is completely portable, containing batteries, electrodes, and electrode stand in one case as illustrated in the centre column. The equipment also includes buffer solutions, beaker, and distilled water, enabling pH measurements to be made at any location. The range is from 0-8 and 7-15 pH on a 3½ in. scale meter.

A simpler model is also available for use with external batteries. Type numbers : D.147 A and D.449 A.

Muirhead and Co., Ltd.
Elmers End, Beckenham, Kent.

Bridge and Electronic Voltmeter

SERIES 666 comprises an A.C. Bridge for measurement of resistance and capacitance, together with a highly sensitive electronic voltmeter arranged to measure A.C. (peak) and D.C. volts. The meter is provided with an illuminated scale which also serves as an ON-OFF indicator.

Provision is also made for testing leakage of capacitors and for checking the power factor of capacitors on all ranges of capacitance.

Ranges : 1 ohm to 10 megohms in six ranges. Accuracy 3%. 10 pF. to 100 *u*F. in six ranges. Accuracy 3% over the majority of scale.

Voltmeter : 100,000 ohms/V. six ranges covering 1 V. to 500 V.D.C. and 10 V. to 500 V. A.C.

Dimensions : 11⅛ in. by 9¼ in. by 6 in. high. Price £39 10s.

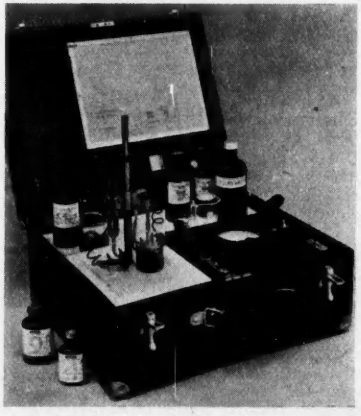
Measuring Instruments (Pullin) Ltd.

Ceramic Miniature Tubular Capacitors

NEW " Hi-K " ceramic capacitors combine small dimensions with high capacitance, and are suitable for incorporating in miniature H.F. equipment, television, and F.M. receivers.

The largest of the three types shown provides a capacitance of 1,000 pF. from each of the three connexions to a common ground. All types are now available.

United Insulator Co. Ltd.
Oakcroft Rd., Tolworth, Surrey.



A Universal Dial Drive System

A STANDARD dial drive system which has made possible a high degree of production standardisation and yet gives almost unlimited flexibility of design has been developed by The Plessey Company.

Standard unit parts will be produced as stock items which can be assembled to manufacturers' specifications in a variety of ways without further tooling. These will be delivered as self-contained units complete with cord, pointer, scale fixing and associated components, ready for incorporation in the receiver as a final assembly operation.

General styles of dial such as horizontal cursor, vertical cursor and clock types are obtainable, with various arrangements of scale and pointer. Provision has also been made for normal lighting arrangements.

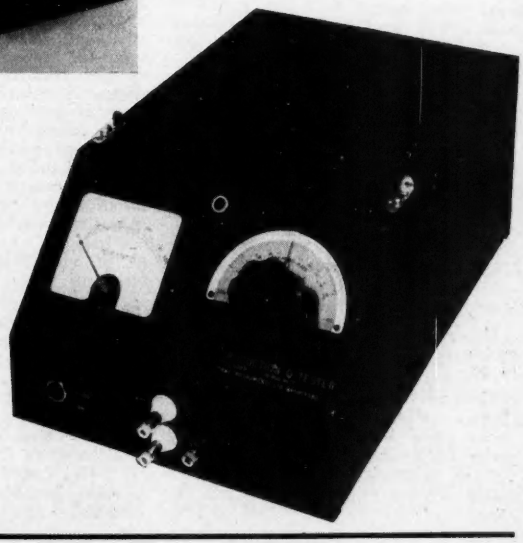
The Plessey Co. Ltd.
Ilford, Essex.

Production " Q " Comparator

THIS instrument has been specifically designed to compare the characteristics of production line coils with a standard coil over the frequency range of 100 kc/s. to 25 Mc/s. by means of plug-in coils. The " Q " range is from 50 to 500 and the magnification calibration is scaled by 0 to 150%. A calibrated precision condenser is used in the oscillator and is directly calibrated in two ranges 60-550 pF. and 110 to 550 pF. The inductance range that can be measured covers inductances from 1jH to 10mH with an accuracy of matching to within 0.1%.

The output is measured on a high impedance valve voltmeter with a meter directly calibrated in percentage Q of the standard reference coil.

Dawe Instruments Ltd.,
Harlequin Rd., Brentford.



NOTES FROM THE INDUSTRY

Sir Clifford Paterson, O.B.E., D.Sc., F.R.S.

The death occurred on Monday, July 26, after a short illness, of Sir Clifford Paterson, at the age of 68.

He joined the General Electric Co., Ltd., in 1919 to establish and direct the G.E.C. Research Laboratories. Under his guidance, these laboratories, which began with a staff of 29, have developed into the largest of their kind in the country with a present staff of 1,750. He was appointed to the board of the G.E.C. in 1941 and received his knighthood in the Birthday Honours List of 1946.

Sir Clifford was past-president of the Institution of Electrical Engineers, of the Institute of Physics, of the Illuminating Engineering Society and of other scientific bodies.

Sydney G. Brown, F.R.S.

Mr. S. G. Brown, whose name and initials are well-known to all radio pioneers, died at his home at Sidmouth, aged 75, on August 7.

He will always be remembered for the Brown headphone, a reed-type receiver with a small aluminium cone diaphragm which was first patented in 1910 and became the standard for high quality sensitive headphones in the war of 1914-18.

Another well-known invention was his microphone relay, for the magnification of feeble currents before the use of the valve rendered it obsolete. In 1914 these relays were in use in the R.A.F. and were the sole means of receiving audible signals in an aeroplane at that time. S. G. Brown's final achievement was the gyro-compass, which has been fitted as standard on many Admiralty and shipping company vessels.

He was his own designer, and in addition to founding the firm of S. G. Brown, Ltd., was the founder and first chairman of the Telegraph Condenser Co.

Alex Moody

When the 1949 Radiolympia exhibition opens, the genial presence of Alex Moody will be missed by the many exhibitors for whom he had a friendly word on his tour round the stands.

He died suddenly on August 1 on his return from the Continent, at the age of 62.

He had organised on behalf of the Radio Manufacturers' Association (later, the Radio Industry Council) every radio exhibition since 1928 and the last one with which he was associated will be remembered as his best effort.

Mathematical Tables for Science and Industry

It is considered that important investigations in science, mathematics, and industry may be held up by the absence of relevant mathematical tables. Several important tables have been produced by the British Association through its Mathematical Tables Committee, and the work has now been transferred to the Royal Society. A special Mathematical Tables Committee has been established to continue and extend the earlier work. This committee would be glad to receive suggestions from industrial and Service research groups or individual investigators relating to existing needs in their special fields. Requests for assistance may be met either by advice as to the most economical way of producing the desired tables, or by an undertaking to produce them under the auspices of the Royal Society, or, in exceptional cases, by a grant towards the cost of tabulation or publication. Inquiries should be addressed to the Assistant Secretary, The Royal Society, Burlington House, London, W.1.

Television Progress in the U.S.A.

According to the Federal Trade Commission there are 22 television stations at present in operation in the U.S.A.; construction of an additional 71 has been authorised and applications relating to 192 more are under consideration by the F.C.C.

It is estimated that there are more than 200,000 television receiving sets in use, of which fully 180,000 represent retail sales during 1947. Production of new television receivers during 1948 is expected to amount to 600,000.

International Television Corporation Ltd.

With registered offices at 63/64 New Broad Street, London, E.C.2, this concern is now operating as a new company called Nagard, Ltd. Their laboratory and works are at 245 Brixton Road, London, S.W.9, where all correspondence on their products (Nagard oscilloscopes and other electronic apparatus) should now be sent.

Newton Victor Ltd.

The formation of this new company is announced. It amalgamates the activities of Victor X-ray Corporation, Ltd., Newton & Wright, Ltd.. and the X-ray research and manufacturing interests of Metropolitan-Vickers Electrical Co., Ltd., under the ægis of the Associated Electrical Industries, Ltd.

Head offices of Newton Victor, Ltd., will be at 15 Cavendish Place, London, W.1 (LAN 4074) with branch offices and service establishments elsewhere in Britain.

Harbour Supervision Radar for Liverpool

This installation constructed by the Sperry Gyroscope Co., Ltd., was officially opened by the First Sea Lord on July 30.

There are two notable departures from preliminary details, which were given on p. 268 of the August, 1947, issue of ELECTRONIC ENGINEERING. In the final installation there are six C.R. Tube displays (by A. C. Cossor, Ltd.), instead of the original five, the sixth being a "wandering" display which can cover any section of the harbour area. The scanner mirror is constructed of a series of horizontal slats instead of a solid sheet.

Long Distance Radio Communication

A booklet issued to the Services during the war has now been made more generally available to radio technical workers and students as "Radio Research Special Report No. 17—Fundamental Principles of Ionospheric Transmission," published for the D.S.I.R. by H.M.S.O. price 1s. 6d. (U.S.A. 55 cents), by post 1s. 8d.

Eddystone "640" Receiver

Stratton & Co., Ltd., announce that as a counter-attraction to the large number of ex-Government disposal receivers now on the market they have decided to reduce, still further, the price of their "640" receiver to £27 10s. 0d. Hire purchase facilities are being made available, the receiver being fully guaranteed for twelve months.

Mullard: Hallicrafter Trade Agreement

Mullard Electronic Products, Ltd., have concluded an agreement with Hallicrafters, Inc., of Chicago, whereby Mullards have the right to manufacture to all Hallicrafter Communication designs. Mullards will be responsible for the representation of Hallicrafters in the U.K., Eire, and Australia, this being separate from their world sales rights as Mullards. For the time being inquiries should be addressed to the Communications Division of Mullard Electronic Products, Ltd.

Change of Address

The Publicity Department of *British Insulated Callender's Cables, Ltd.*, has now removed to 21 Bloomsbury Street, London, W.C.1. Telephone No.: MUSeum 1600.

Radio Gramophone Development Co., Ltd., has also moved its Publicity Department to 21 Bloomsbury Street, and its London Depot to 3/4 Hampton Court Parade, East Molesey, Surrey.

Purchase Tax on P.A. Apparatus

The protests made by the Electronic Manufacturers' Association on the recently announced ruling of the Commissioners of Customs and Excise that the whole assembly when housing a gramophone should be liable to purchase tax at 66⅔ per cent. have met with some success. The Commissioners have now notified the Association that where the apparatus consists of a series of P.A. type units, each in a self-contained, enclosed cabinet, which are stacked vertically without being enclosed in an outer cabinet, such apparatus will only be liable to purchase tax in respect of the gramophone and wireless receiving units, when the apparatus is put up for P.A. use.

Engineering Draughtsmen and Designers

The Council of the Institution of Engineering Draughtsmen and Designers has evolved a new examination syllabus which is likely to come into force in the near future. It will be officially announced when the 5th edition of the "Rules for Examination" is published.

The new syllabus will be based on three separate examinations, *i.e.*, preliminary, intermediate, and final, leading to Associate Membership (A.M.I.E.D.). Candidates who have passed the first two sections will become eligible for the lower class of graduateship (Grad.I.E.D.). Further information can be obtained from the Secretary, the I.E.D., King Edward Building, 341 Regents Park Road, London, N.3.

Production of Magnetic Dust Cores

French Patent No. 928464. A new method of producing dust cores by injection moulding is described in "Metal Powder Report," privately circulated to a limited number of subscribers by *Powder Metallurgy, Ltd.*, 1-19 *New Oxford Street, London, W.C.*1.

"The Spectrographic Analysis of Tin and Tin Lead Solders"

A new booklet published by and obtainable, free of charge, from the Tin Research Institute, Fraser Road, Greenford, Middx., gives a comprehensive summary of present knowledge on the subject of Metallurgical Analysis of Tin and Tin Lead Alloys by the Spectrograph.

Johnson, Matthey & Co. Ltd., and Australia

It is announced that as from July 1, 1948, an amalgamation is to take place between Johnson Matthey & Co., Ltd., and Messrs. Garrett & Davidson Pty., Ltd., of Sydney, Australia.

Change of Telephone Number

Goodmans Industries, Ltd., Lancelot Road, Wembley, Middlesex, have a new telephone number: WEMbley 1200 (8 lines).

Morganite Resistors Ltd.

The carbon resistor department of the Morgan Crucible Company, Battersea, has expanded to such an extent that the business has been transferred to a large modern factory at Jarrow, Co. Durham, and a new company, Morganite Resistors, Ltd., has been formed to handle this range of their products.

Mr. E. T. Tregenza is the managing director, Mr. J. Thomson the sales and commercial manager, with Mr. R. H. Wilson as the London branch manager at the Morgan Crucible Company's offices.

Gramophone Record Library

Frequency records and most of the recordings which, from a technical point of view, have been specially recommended as suitable for demonstrating high fidelity equipment are now available on loan from: *The Yorkshire Gramophone Library,* 168 *Briggate, Leeds* 1.

Electronic Applications Research Laboratory

The Electronic Applications Research Laboratory exists primarily for the purpose of investigating practical applications of the electronic art. The work is under the direction of two experienced electronic consulting engineers, Donald W. Thomasson and Peter G. S. Jackson.

In connexion with this work a number of consultant services are operated by E.A.R.L., and these are available to all persons concerned in any way with the electronic industry.

E.A.R.L. is not a manufacturing concern, though model shop facilities are available for the construction of prototypes, the advice given by the engineers is therefore entirely impartial and based solely on technical fact.

The "Recordon" Dictating Machine

A direct development of the magnetic recorders produced during the war years, this new piece of office equipment is of particular interest because of the principles it employs.

Most office dictating machines use a direct cut wax cylinder which, having to be shaved after use, has a very limited life. The "Recordon," however, presents a magnetic recording on a specially coated paper or plastic disk. As the recording is magnetic it will last indefinitely without loss of quality, or it can be magnetically and instantly erased by a single revolution of the turntable. In this way it can be used over and over again.

The plastic records are intended, chiefly, for filing, but the paper ones can be folded after recording, posted and played back by the recipient.

The "Recordon" is British made, and will be available in September at a price of £45. Further details are obtainable from Thermionic Products, Ltd., Pratt Walk, London, S.E.11.

Publications Received

Products and Services.

A well illustrated and highly descriptive publication (No. 1,000) issued by *Johnson, Matthey and Co., Ltd.*, 73/83, *Hatton Garden, London, E.C.*1.

Macmillan's Scientific and Technical Books.

A 199 page catalogue of their Scientific and Technical books published in this country, the U.S.A. and Canada and obtainable from: *Macmillan and Co., Ltd., St. Martin's Street, London, W.C.*2.

Standardisation of Radio Frequency Cables.

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F.M. Transmission and Reception

J. F. Rider and S. D. Uslan. (J. F. Rider Publishing Co. 416 pp. Cloth price $2.70. Paper price $1.80.)

THE House of Rider is well known as a publisher of books for the service man and radio technician as distinct from the engineer. Their approach to a subject is from the simplest possible angle without the use of mathematics, and to the practical man the method has much to commend it. The result is necessarily a verbose style, for what could be stated mathematically in one line may often require a page of words. "F.M. Transmission and Reception" suffers from these practically unavoidable defects, which include a number of "it will be shown later that." Its 400 pages represent good value for money and the diagrams are clearly drawn thus aiding appreciably an understanding of the text. There are nine chapters covering very thoroughly all aspects of F.M. from the American viewpoint. Short appendices on reactor valve admittances, vectors, powers of ten, the Fremodyne circuit, U.H.F. ground wave signal range, I.F. response curve visual indication and a bibliography complete the book.

Chapter I (Fundamental Considerations) deals with the three well-known types of carrier modulation, amplitude, phase and frequency, in that order. In the reviewer's opinion this is the best method of gaining an understanding of F.M., and the chapter should be very helpful to the uninitiated. On page 12, the suggestion is made that F.M. and P.M. are unresponsive to A.M. whereas it is the limiter at the receiver which suppresses A.M. Emphasis might have been laid on the fact that P.M. is F.M. with bass cut; this helps in appreciating the noise reducing qualities of F.M. Chapter 2 discusses in pictorial manner the meaning of deviation ratio, modulation index and sideband spread in an F.M. wave. There is a useful table of modulation index and effective bandwidth on page 41.

Reactor valves, phase modulators and automatic frequency correction are the subjects of Chapter 3 on the essentials of F.M. transmitters. There is a mistake in Fig. 3.6 (page 59); the reactor valve current i_{AB} is shown as circulating and not according to the text as the input current. On page 74 it is wrongly suggested that the normal a.f.c. circuit returns the oscillator frequency to its original value, and on page 89 the ambiguous statement apears rather appropriately in italics (!) "produces an output that is below 1 per cent. distortion." Chapter 4, Transmitters of Today, gives a very complete circuit description of the F.M. transmitters produced by the major American manufacturers. The balanced modulator and the phasitron tube are fully discussed and the importance of frequency division in frequency-corrected transmitters is well brought out.

Transmitting aerials are the main item of the fifth chapter on the transmission of F.M. signals, which begins with a statment that the U.H.F. aerial for F.M. is different from that for A.M. No elucidation of this is given in the chapter. The "gain" of an aerial system receives clear treatment.

Practical hints and tips on receiving aerials are given in Chapter 6 and the next chapter is concerned with certain aspects of the receiver, mainly the saturated amplifier limiter and the frequency-to-amplitude converter. The ratio detector is touched upon but its limiting action by variable damping does not seem to have been appreciated.

The general impression of the book is that it will provide a useful introduction to F.M. for the operator and technician of limited technical knowledge. The engineer will find it readable but may be impatient at the proliferation of words in place of concise mathematical statement.

K. R. STURLEY

The Technique of Micro-Wave Measurements

McGraw-Hill Book Co. Price $10. Edited by Carol G. Montgomery. Vol. II of the Radiation Laboratory Series. (Massachusetts Institute of Technology.)

THE wartime development of radar necessitated considerable attention being paid to measuring techniques for use in the micro-wave range (1,000 to 30,000 Mc/s), indeed it is probably true to say that the success of radar was conditioned by progress in the art of measurement. Much of this progress was recorded in the confidential reports of the various Services, industrial and university laboratories in Great Britain, America and in the Dominions, and has not, until comparatively recently, been available to the general public. In this country a considerable release of information has taken place chiefly through the Radiolocation Convention of the Institution of Electrical Engineers (March-May, 1946); in America the staff of the Radiation Laboratory of the Massachusetts Institute of Technology (which was responsible for much of the radar development in the U.S.A.) stayed on for six months after the end of the war in order to write up the work which had been done, in the form of the 28 volumes of the Radiation Laboratory series.

The "Technique of Micro-wave Measurements" is Vol. 11 of the series, it describes methods of measurement likely to be of use to future workers in this field. The methods described are grouped under four main headings:—

REVIEWS

1. Power generation and measurement.
2. Wavelength and frequency measurement.
3. Measurement of impedance and standing waves.
4. Attenuation and radiation measurements.

Section 1 describes micro-wave power sources such as the klystron oscillator, methods of frequency stabilisation of the power source and methods of power measurement using thermistors, bolometers and water-load watt-meters. Signal generators for testing receivers are discussed, together with noise generators for the measurement of noise-factor.

Section 2 deals with the measurement of wavelength by means of resonant cavities, and frequency using frequency-multiplier techniques.

Section 3 is devoted to the principles of impedance measurement by the standing-wave ratio method and by impedance bridges using wave-guides; the measurement of dielectric constant and power factor are also discussed.

Section 4 deals with the design of co-axial and wave-guide attenuators using modes below the nominal cut-off frequency, and resistive strip attenuators. The application of directional couplers to the measurement of forward and reverse power is explained. The final chapter is concerned with measurement of aerial gain, directivity and phase-front patterns.

An excellent balance between theory and practice has been achieved in this book, and the references to the original work are on the whole adequate. Although the scope is broad the treatment of the subject is very thorough and there is little doubt that the volume will be of considerable value to all concerned in the micro-wave art.

W. J. BRAY

Radio Laboratory Handbook

M. G. Scroggie. 424 pp. 216 Figs. (Published for the "Wireless World" by Iliffe & Sons, 12s. 6d. Nett.)

THIS is the fourth edition of Mr. Scroggie's book, which well deserves the title of "Handbook," and the reader would not begrudge the increase in weight if the next edition were increased by 50 per cent. Mr. Scroggie's apparatus is practical, it has worked over a long period, and while it is possible nowadays to produce neater and more compact laboratory equipment, it is doubtful whether any great improvement in efficiency would result.

This book should be on the shelves of all research laboratories using electronic methods, if only for the sound advice on experimental technique.

G. PARR

Broadcast Operators' Handbook

By Harold E. Ennes. (262 pp. John F. Rider, $3.3.)

ALTHOUGH the literature of radio is voluminous it contains little on the subject of the practical operation of broadcasting equipment and the techniques that have been evolved to bring the standards of transmitted programmes nearer to perfection. Mr. Harold Ennes has helped to repair this omission by writing a book that covers the whole field of broadcasting operations from the microphone to the transmitter.

The book starts with a chapter on the basic principles of sound pick-up, followed by an account of control room operations and the technique of microphone placing. Next, remote pick-ups, or outside broadcasts, are dealt with in some detail, each kind of programme that may come under this heading being described. Three chapters are devoted to transmitter operation and three to preventive maintenance, including specimen daily, weekly, and monthly routines. The apparatus commonly used in American control rooms and the principles underlying its design are covered, as are also the design of studios and the selection of sites for broadcast transmitters. Finally, a forty-page appendix contains descriptions of specific R.C.A. testing and monitoring equipment, with instructions for its operation.

A book such as this, written about American equipment and for American operators and technicians, inevitably contains some material that is of little practical value to broadcasting engineers in this country, where the organition, apparatus and methods are so very different. There is, nevertheless, much in it that will be of interest both to engineers over here who are primarily concerned with the operation and maintenance of broadcasting apparatus and to those who work on the production side of broadcasting. The book is very readable and it is well illustrated with diagrams and photographs.

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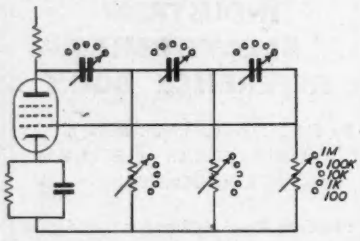
CORRESPONDENCE

Circuit Diagrams

DEAR SIR,—In the June, 1948, issue of ELECTRONIC ENGINEERING there appears another excellent article by Mr. Bainbridge-Bell which again shows the way to clearer circuit diagrams. In this connexion may I mention two symbols "invented" during the war with the same object in view? The bank of switched capacitors (*e.g.*, as in time bases), and the bank of switched resistors, (*e.g.*, as in a decade box). Both symbols are self-explanatory, and can simplify a circuit diagram considerably.

Another simplification, much used during the war, was to show indirectly heated valves without a heater in the envelope, connexion to the cathode being made from below and in the centre, implying a uni-potential cathode. This is particularly useful in circuits where valves are in series, as the heaters may then be drawn away from the valves and marked V_1V_2 etc. It also makes the valve look like a straight through "valve" device in the real sense, and not the rather lop-sided thing which would fall over if it were not for the wire going to it!



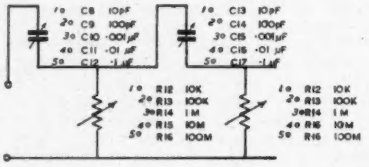
One minor criticism of Mr. Bainbridge-Bell's article was the repeated mention of condensers. "Capacitor" doesn't seem too bad a word after a bit of practice and "resistor" is now almost universally used.—Yours faithfully,

C. H. BANTHORPE

DEAR SIR,—I like Mr. Banthorpe's representation of switched resistors and capacitors and am adopting it forthwith.

As I am dealing with ganged switches, I have turned the capacitors through a right-angle in order to keep the "switch-arms" parallel when they are in the anti-clockwise position.

I am marking the contact studs with stud numbers, component reference (*e.g.* R12) and component value.



I would not adopt the centre connexion to the cathode, as I like to choose the end to which I make connexion to distinguish among cathode-follower stages (right-hand end) and other types (left-hand end).

I agree with the system for drawing series heaters separate from the valves.

Concerning condensers and capacitors:

In 1944, when these recommendations were first drafted, the services were not yet "capacitor-conscious"; most of the "condensers" in my article are in quotations from the inter-service publication.

I now try to use "capacitor"—there is one example in my article—but I am reluctant to abandon good old expressions such as "de-coupling condenser," "leaky condenser."

I say that a de-coupling *condenser* is a *capacitor* used in certain well-known network.—Yours truly,

L. H. BAINBRIDGE-BELL

Modulating Light Beams

SIR,—The publication in a recent issue of *The Journal of Applied Physics* of a note on "The use of a Cavity Oscillator for a Kerr Electro-Optical Light Shutter"[1] leads me to revive the suggestion that the process involves, as Smith-Rose has put it,[2] amplitude modulation of the light beam by the radio frequency voltage.

It occurred to me, in 1945, to look into this matter, as I was interested in the production of the "side-frequencies" inherently involved in the amplitude modulation process.

It is believed that the Kerr Effect was first used by Karolus and Mittelstaedt[3] and, later, by Anderson[4] for the determination of the velocity of light.

The radio frequencies used by these investigators were so low, relative to the frequency of the light wave, that any side frequencies produced would not be resolvable.

If, however, a radio frequency of 3,000 Mc/s. were used, then the side frequencies should appear on each side of the "carrier," separated from it by a "distance" of the order of 0.035 A.U. for a monochromatic light wavelength of 6,500 A.U.

A modulating frequency of 10,000 Mc/s. would produce a corresponding increase in the bandwidth.

The experimental difficulties are not to be under-rated. The American investigators have solved the problem of obtaining a sufficiently high voltage to modulate the light beam with the Kerr Effect by the use of a cavity resonator. This was suggested to me by Professor J. Greig about three years ago.

It does not seem to be impossible that the use of a cavity resonator might produce magnetic fields of such order that the Faraday Effect would manifest itself.

The production of "side" frequencies in this manner, if they are observable, will have to the physicist and the radio engineer a significance of, I trust, some value.—Yours faithfully,

D. O'BRIEN

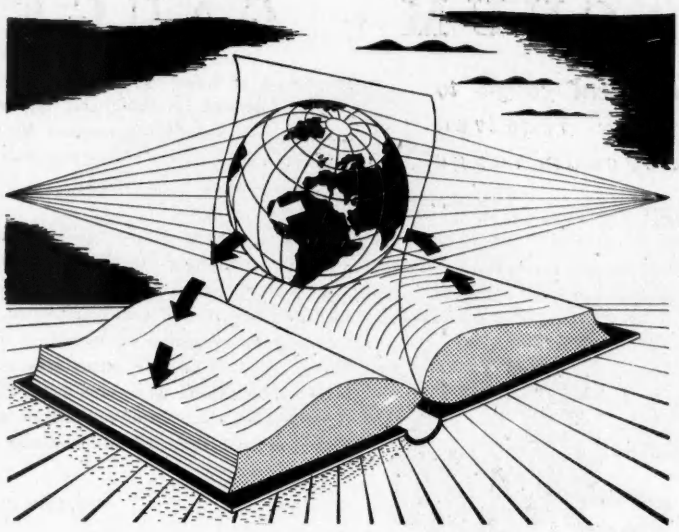
References

[1] Lapsley, Snoddy and Beams. The use of a cavity oscillator for a Kerr electro-optical light shutter. *Journal of Applied Physics*. January, 1948. p.111.

[2] R. L. Smith-Rose. Chairman's address, Wireless Section, I.E.E. *J.I.E.E.* Vol. 90. Part 3. 1943, p. 2.

[3] Karolus and Mittelstaedt. Determination of the velocity of light by the application of the Kerr electro-optical effect. *Physicalische Zeitschrift*, 1928, 29. p. 698.

[4] W. C. Anderson. Final measurement of the velocity of light. *Journal Opt. Soc. Am.* 1941, 31. p. 187.



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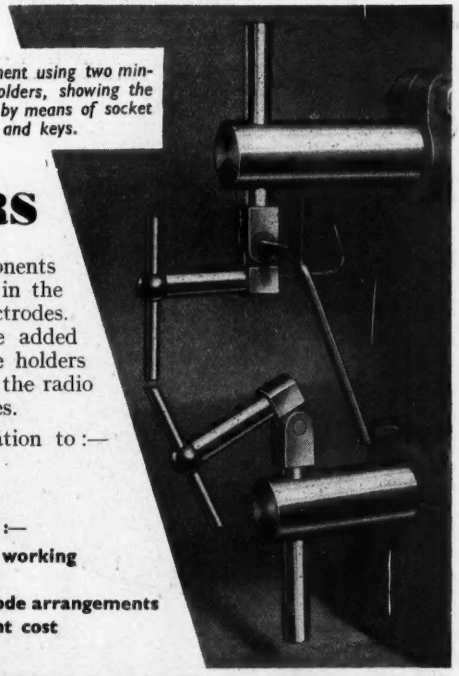

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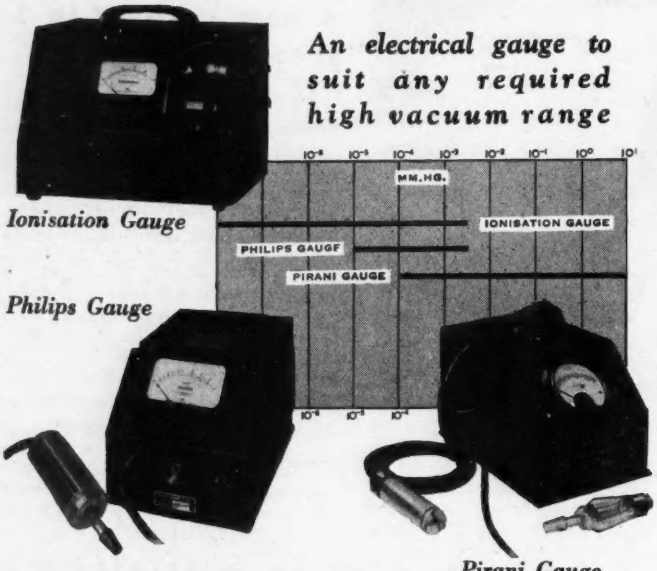

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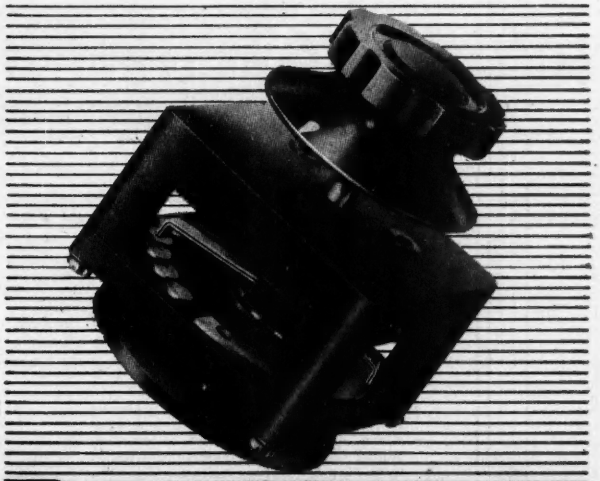

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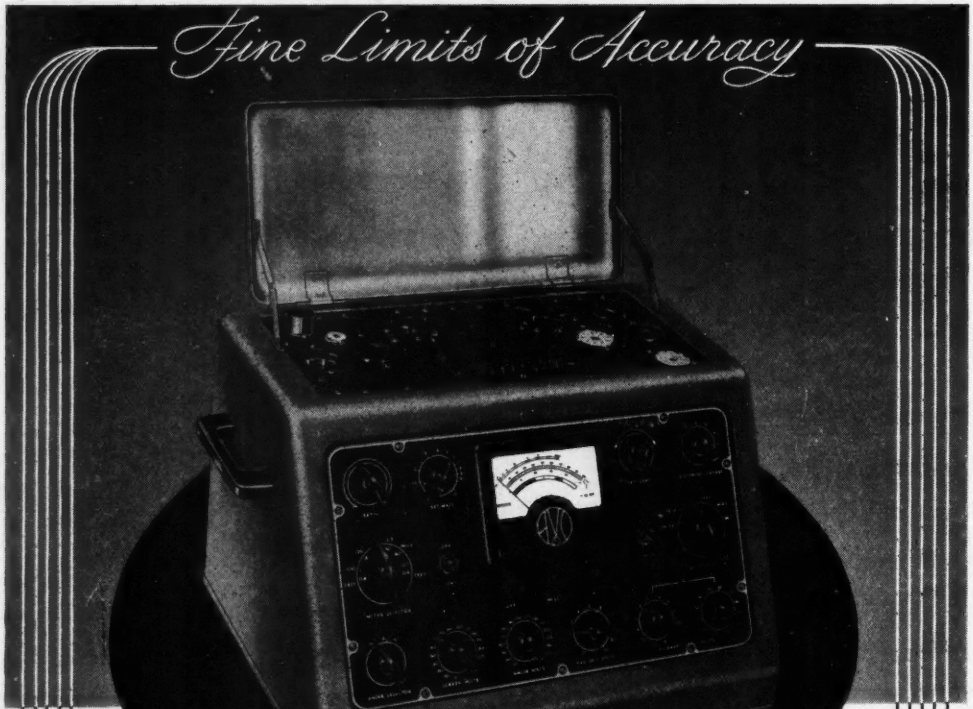

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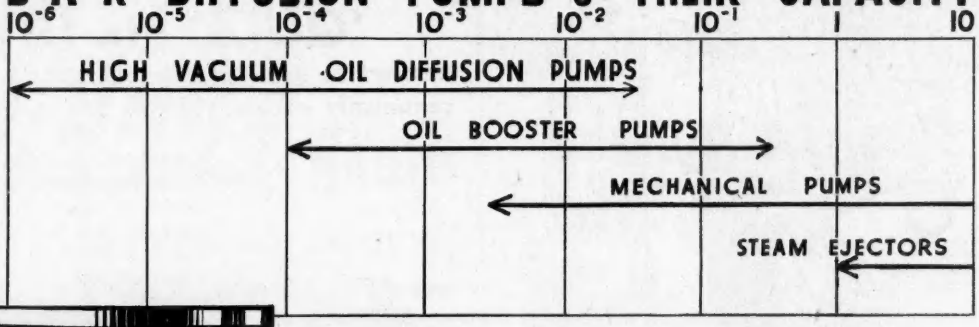

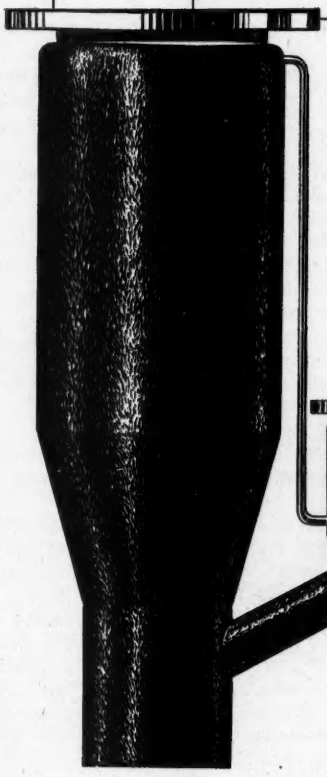

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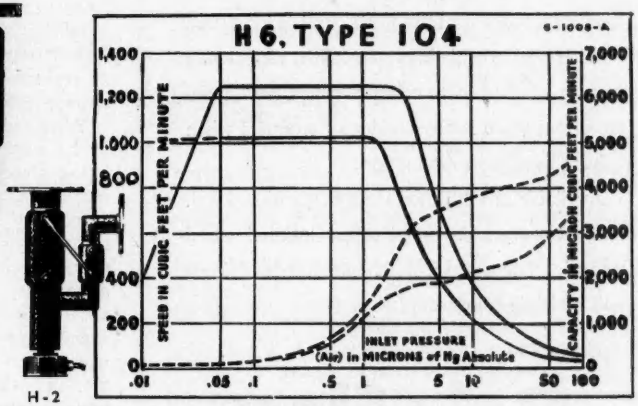

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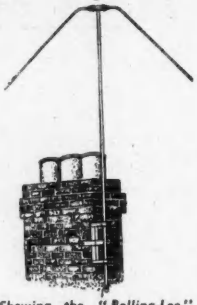

Showing the "Belling-Lee" L.606 Inverted "V."

Question 40. *Why the funny shape? (asked many times at recent exhibitions, referring to the "Belling-Lee" Inverted "V" television aerial).*

Answer 40. The purpose behind its design was the production of an aerial more compact than the orthodox dipole.

The inverted "V" form lends itself to erection in the average attic or loft, high up under the ridge, well away from plumbing and conduits, and gives good results. Installation engineers appreciate the impracticability of installing a normal dipole in such locations, while the indoor installation of a dipole and reflector array is well nigh impossible.

For areas of high field strength, it is suggested that up to ten miles for outdoor use, five miles for attic use should be taken as a general guide, for distance from transmission stations.

When using a simple dipole many television installations require the use of resistive attenuators to reduce the strength of the incoming signal to the appropriate level.

With this new aerial such attenuation is not likely to be necessary, yet the aerial has the advantage of being directional, with a very high ratio of maximum/minimum pickup. This feature is most useful in removing "ghosts" and for the improvement of signal-to-noise ratio in localities where interference is troublesome, particularly from electronic heating apparatus, e.g., diathermy. Hitherto, the only answer has been the use of a relatively expensive dipole and reflector array even in districts where the use of such an aerial necessitated the generous application of resistive attenuation. The effective band width is somewhat greater than that of the conventional type, and thus takes full advantage of the increased band width now being transmitted on the vision channel.

L606 Chimney dipole.....£4 10 0
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Feeder extra

TO BE CONTINUED...

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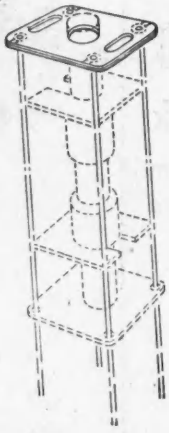
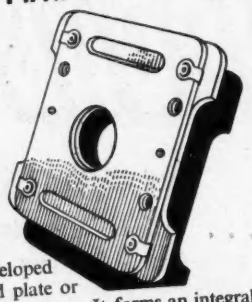


Type SMS. 102 suitable for miniature I.F. transformers ¾" square.

Type SMS. 202 suitable for standard I.F. transformers 1⅛" square.



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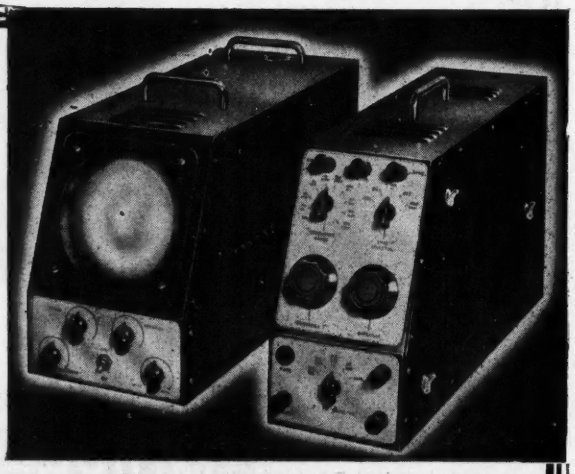

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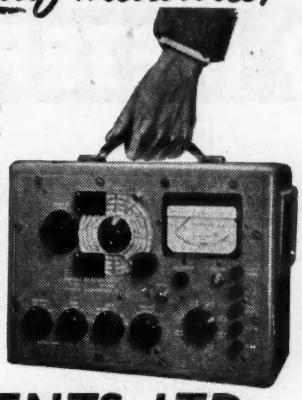

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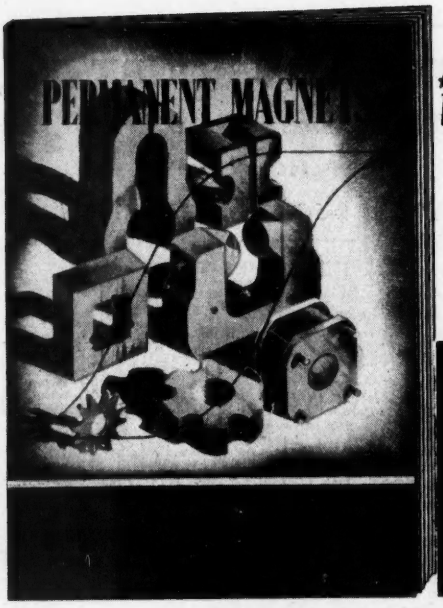

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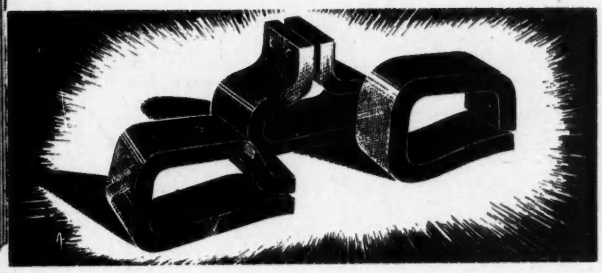

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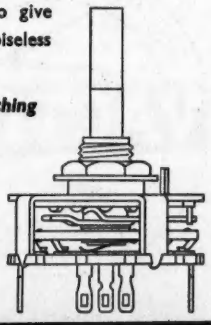

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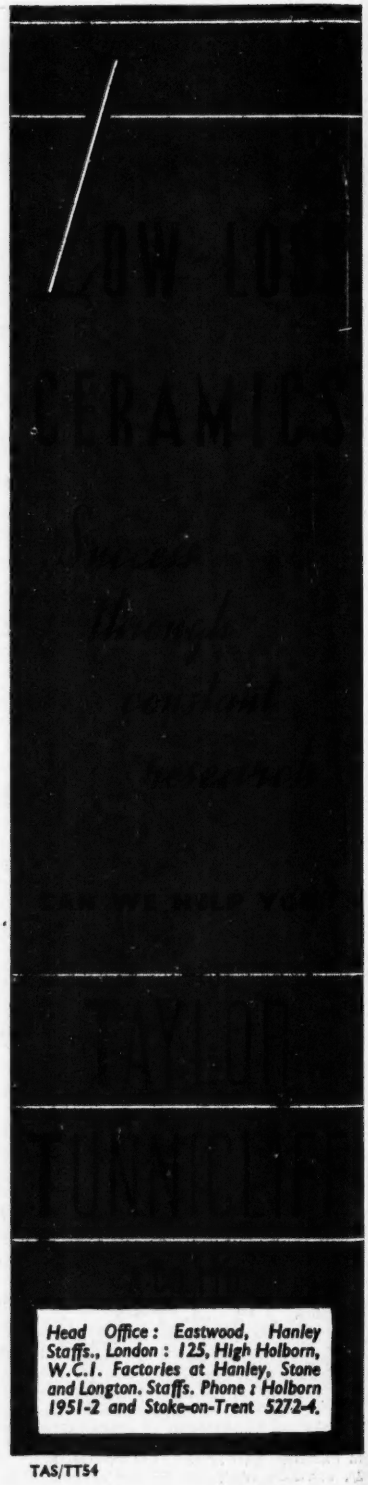
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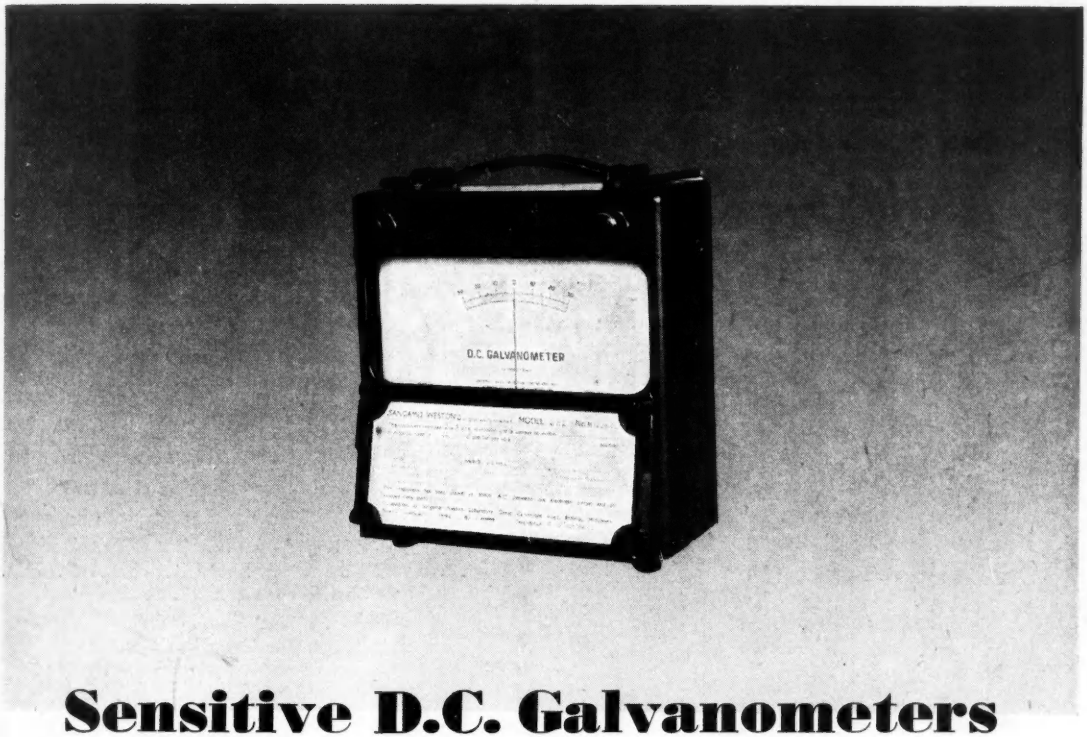

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A feature of these Weston D.C. Galvanometers is their high sensitivity which is combined with rapid response characteristics and robust construction. The instruments operate on the permanent magnet moving-coil principle and are supplied in six standard sensitivities. If required, six sensitivities can be incorporated in one instrument, selected by means of a rotary switch. Other features of these galvanometers include a double-pivot type moving system, spring-loaded jewels, magnetic shielding, a 60-mm. scale with a knife-edge pointer and a neat bakelite case fitted with a hinged flap to protect the scale glass. The instruments are suitable for portable or bench use and are known as Model S82 Galvanometers.

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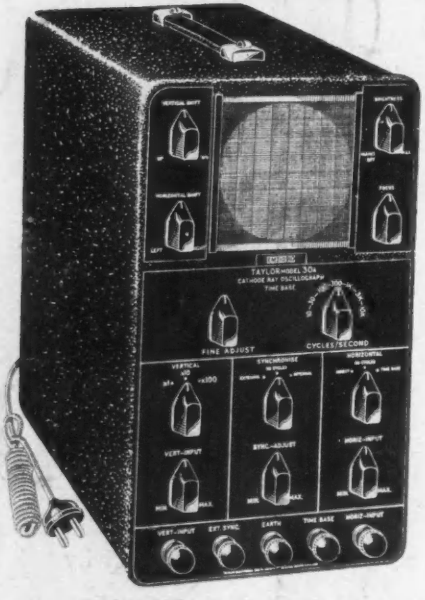
Announcing . . . the New Taylor Cathode Ray Oscillograph



This instrument is a general-purpose oscillograph using a 3½-inch tube. A linear time-base generator and a push-pull vertical amplifier are incorporated.

CATHODE RAY TUBE. A 3½-inch tube having a green fluorescent screen and electrostatic deflection is used in this instrument.

AMPLIFIER. A push-pull amplifier for the vertical plates is fitted and provided with a switch to give ratios of 1, 10 and 100 in amplification. The amplifier is designed to cover the audio frequency range, and useful amplification is available up to 100 k/c.

LINEAR TIME BASE. A linear horizontal time base is provided with coarse and fine frequency controls covering a range of 10-10,000 c.p.s. A switch and adjustable control enable the time base to be synchronised either externally or to the mains supply frequency or by the signal applied to the vertical amplifier.

SINUSOIDAL SWEEP. Provision is made for horizontal sweep at mains frequency. This enables quick identification of mains hum.

CASE. This instrument is mounted on a steel panel and fitted into a steel case. Both panel and case are finished in crackle enamel.

POWER. The oscillograph is operated from A.C. mains, 110 or 200-250 volts A.C., 40-100 cycles. Consumption is 25 watts.

DIMENSIONS. 15½ by 12¾ by 7¼ in.

WEIGHT. 24 lb.

MODEL 30A

PRICE £29 · 10 · 0

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